# Phase II Vitals Signs Monitoring Plan

## Upper Columbia Basin Network (UCBN)
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Prepared by:

Lisa Garrett
Network Coordinator
University of Idaho
Department of Fish and Wildlife
Moscow, ID 83844-1136

Tom Rodhouse
Ecologist
365 NW State St.
Bend, OR 97701

Leona Svancara
Data Manager/Spatial Ecologist
University of Idaho
121 Sweet Ave., Suite 117
Moscow, ID 83844-4061

Christopher C. Caudill, Ph.D.
Fish Ecology Research Lab
University of Idaho
Department of Fish and Wildlife
Moscow, ID 83844-1136

**Upper Columbia Basin Network Parks**

Big Hole National Battlefield (BIHO)
City of Rocks National Reserve (CIRO)
Craters of the Moon National Monument & Preserve (CRMO)
Hagerman Fossil Beds National Monument (HAFO)
John Day Fossil Beds National Monument (JODA)
Lake Roosevelt National Recreation Area (LARO)
Minidoka Internment National Monument (MIIN)
Nez Perce National Historical Park (NEPE)
Whitman Mission National Historic Site (WHMI)

# Phase II Vital Signs Monitoring Plan

# Upper Columbia Basin Network

Signature:

Lisa Garrett, UCBN I & M Coordinator — Date

Jason Lyon, Resource Manager Nez Perce NHP — Date
UCBN Science Advisory Committee Chairman

Jim Hammett, Superintendent John Day Fossil Beds NM — Date
UCBN Board of Directors Chairman

Penny Latham, PWR I & M Coordinator — Date

## Executive Summary

Knowing the condition of natural resources in national parks is fundamental to the National Park Service's (NPS) ability to manage park resources "unimpaired for the enjoyment of future generations". The NPS has implemented a strategy designed to institutionalize natural resource inventory and monitoring on a programmatic basis throughout the agency. The effort was undertaken to ensure that the approximately 270 park units with significant natural resources possess the resource information needed for effective, science-based managerial decision-making and resource protection. The national strategy consists of a framework having three major components: 1) completion of basic resource inventories upon which monitoring efforts can be based; 2) creation of experimental prototype monitoring programs to evaluate alternative monitoring designs and strategies; and 3) implementation of ecological monitoring in all natural resource parks.

Parks with significant natural resources have been grouped into 32 monitoring networks linked by geography and shared natural resource characteristics. The network organization will facilitate collaboration, information sharing, and economies of scale in natural resource monitoring. Parks within each of the 32 networks work together and share funding and professional staff to plan, design, and implement an integrated long-term monitoring program. The Upper Columbia Basin Network (UCBN) is made up of 9 NPS units located in western Montana, Idaho, eastern Washington, and central Oregon.

The complex task of developing ecological monitoring requires a front-end investment in planning and design to ensure that monitoring will meet the most critical information needs and produce ecologically relevant and scientifically credible data that are accessible to managers in a timely manner. Network monitoring programs are being developed over a four-year time frame with specific objectives and reporting requirements for each of three planning phases. This document is the second of three scheduled reports. Its purpose is to 1) outline UCBN monitoring goals and the planning process we will use to develop the monitoring program, 2) summarize existing information concerning park natural resources and identify the most significant resources, resource concerns and issues across the network, 3) introduce the ecological context for Network parks and provide a conceptual model framework for Columbia Basin ecosystems, and 4) describe the process used to prioritize and select vital signs for UCBN parks.

The major challenge of the Vital Sign Prioritization process has been assembling a suite of vital signs that are insightful to park-level management concerns, provide understanding and status of ecosystem condition, and share value across all the parks in the network. The thirteen vital signs selected for monitoring in UCBN parks include: invasive/exotic plants, sagebrush-steppe vegetation, land cover and use, riparian vegetation communities, stream/river channel characteristics, surface water dynamics, water quality/macroinvertebrates, aspen, osprey, bat communities, limber pine, camas lily, and sage grouse.

The Network will use existing data collected by other agencies to complete the integrated monitoring program. The compilation of existing data will provide the Network with a well-balanced program at a fraction of the cost. Examples of data that will be compiled from existing

sources include ozone, visibility, air contaminants, weather and climate, water chemistry, toxics, aquatic macroinvertebrates, insect pests, and fire and fuel dynamics.

Over the next two years (2005-2007), network staff, park managers, and researchers from the scientific community will be engaged in the process of writing protocols for the thirteen vital signs selected for monitoring. The network will develop and test detailed monitoring protocols for implementation in the summer 2007.

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# Chapter 1: Introduction and Background

## I. Scope of Phase II Report

In 1999, the National Park Service (NPS) launched the Natural Resource Challenge, a 5-year program designed to strengthen natural resource management in the Nation's national parks (National Park Service 1999). The single biggest undertaking of the Challenge was to augment ongoing park inventory and monitoring efforts into an ambitious comprehensive nationwide program. The Servicewide Inventory and Monitoring (I&M) program was introduced to 270 parks identified as having significant natural resources. Under this program, parks have been organized into 32 networks to conduct long-term vital signs monitoring. Each network links parks that share geographic and natural resource characteristics, allowing for improved efficiency and the sharing of staff and resources. The Upper Columbia Basin Network (UCBN) has received funds to conduct planning activities and is expected to be fully funded for the monitoring program in FY 2006.

The UCBN Vital Signs Monitoring Plan is being developed over a multi-year period following specific guidance from the NPS Washington Office (WASO) (National Park Service 2003a). Networks are required to document monitoring planning progress in three distinct phases (see Table 1.1) and to follow a standardized reporting outline. Each phase of the report requires completion of specific portions of the outline.

The Phase II Report includes Chapter One (Introduction and Background), Chapter Two (Conceptual Models), and Chapter Three (Vital Signs) of the monitoring plan. Other chapters will be developed for the Phase III Monitoring Plan (complete). This document presents the UCBN framework and approach to planning for vital signs monitoring and sets the stage upon which the program will be developed. Specifically, this report:

- introduces network monitoring goals and describes the process we will use to select key resources and monitoring questions;

- summarizes existing information concerning park natural resources and identifies the most significant resources and resource threats for each park across the network;

- introduces the ecological context of the Columbia Basin and provides conceptual models of significant Columbia Basin ecosystems.

- introduces a list of selected vital signs and associated monitoring objectives identified for the UCBN through a series of scoping workshops and a comprehensive literature review.

The Phase II Report will describe in detail the working list of vital signs and associated monitoring objectives, as well as the process taken by the network to identify and prioritize vital signs. The Phase III Report will constitute the first full working version of the UCBN Monitoring Plan and will present results of the monitoring design work and planning for implementation.

Table 1.1. Three-phase planning process for Vital Signs development.

| | Goals and Tasks | UCBN Deadlines |
|---|---|---|
| Phase I | Description of Monitoring Objectives and Needs, Data Mining Results and Conceptual Model Development | October 2004 |
| Phase II | Vital Signs Prioritization, Selection, and Rationale | October 2005 |
| Phase III Initial Draft | Monitoring Design | December 2006 |
| Phase III Peer-review | Monitoring Design | October 2007 |

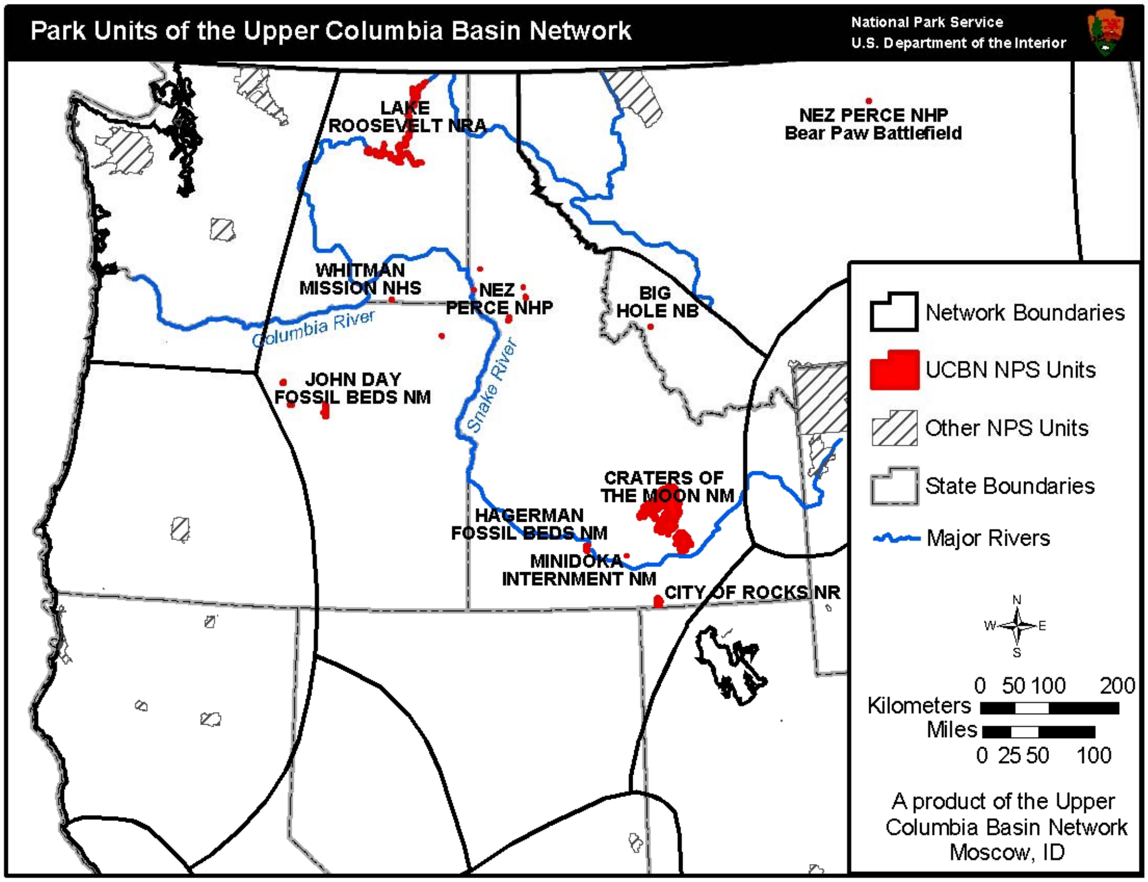
## II. Network Overview

A critical component of the I&M program has been the organization of each of the 270 parks with significant natural resources into monitoring networks. The network organization facilitates collaboration, information sharing, and economies of scale in natural resource monitoring. Each network is guided by a Board of Directors who specifies desired outcomes, evaluates performance for the monitoring program, and promotes accountability. The level of funding available through the Natural Resource Challenge will not allow comprehensive monitoring in all parks, but will provide a minimum infrastructure for initiating natural resource monitoring in all parks that can be built upon in the future.

Parks within each network work together and share funding and professional staff to plan, design, and implement an integrated long-term monitoring program. The complex task of developing a network monitoring program requires a front-end investment in planning and design to ensure that monitoring will meet the most critical information needs of each park and produce scientifically credible data that is accessible to managers and researchers in a timely manner. The investment in planning and design also ensures that monitoring will build upon existing information and understanding of park ecosystems and make maximum use of leveraging and partnerships with other agencies and academic institutions.

The UCBN is made up of nine widely separated NPS units located in western Montana, Idaho, eastern Washington, and central Oregon. Figure 1.1 shows the location of the nine UCBN parks and the boundary of the network. Note that one of the units of the Nez Perce National Historical Park (NEPE), Bear Paw Battlefield, is actually located outside of the network boundary in eastern Montana. This unit and one other network park, Big Hole National Battlefield (BIHO), lie outside the Columbia River Basin, however administratively they are part of the Network. The other network parks lie within the upper Columbia Basin. While all of the units have been identified as having significant natural resources, the majority of parks were actually established to protect cultural and paleontological resources. The upper Columbia Basin holds a rich and fascinating cultural history, and several UCBN parks provide the nationally significant service of chronicling the pre-contact and contact cultures of the Nez Perce and Cayuse people, early pioneer and mission culture, and the tragic conflicts that arose between them. Two UCBN parks also protect and interpret globally significant fossil localities. Most network parks also have some level of natural resource protection language included in enabling legislation or other guidance documents.

Figure 1.1. Map of UCBN park units.




Parks within the network vary in size from 30 hectares to more than 190,000 hectares, and all but two parks are less than 6,000 hectares (Table 1.2). These park units with limited budgets and little staff are not able to provide personnel and funds for many of the natural resource concerns they face. The resources available at the network level will greatly increase their capacity to meet the increasingly complex resource management issues.

Table 1.2. National Park Service Units in the Upper Columbia Basin Network.

| Park | Park Code | State | Acres | Hectares | Originally Established For | | |
|---|---|---|---|---|---|---|---|
| | | | | | Cultural Resources | Natural Resources | Recreation |
| Big Hole National Battlefield | BIHO | MT | 655 | 265 | X | | |
| City Of Rocks National Reserve | CIRO | ID | 14,107 | 5,708 | X | X | X |
| Craters of the Moon National Monument and Preserve | CRMO | ID | 469,711 | 190,081 | X | X | |
| Hagerman Fossil Beds National Monument | HAFO | ID | 4,351 | 1,760 | X | | |
| John Day Fossil Beds National Monument | JODA | OR | 14,056 | 5,688 | X | X | |
| Lake Roosevelt National Recreation Area | LARO | WA | 100,390 | 40,625 | X | | X |
| Minidoka Internment National Monument | MIIN | ID | 73 | 30 | X | | |
| Nez Perce National Historical Park | NEPE | ID | 2,122 | 858 | X | | |
| Whitman Mission National Historic Site | WHMI | WA | 98 | 40 | X | | |

## III. Purpose

### A. Justification

Knowing the condition of natural resources in national parks is fundamental to the NPS's ability to manage park resources “unimpaired for the enjoyment of future generations”. NPS managers across the country are confronted with increasingly complex and challenging issues that require a broad-based understanding of the status and trends of park resources as a foundation for making decisions and working with other agencies and the public for the benefit of park resources. For years, managers and scientists have sought a way to characterize and determine trends in the condition of parks and other protected areas to assess the efficacy of management practices and restoration efforts and to provide early warning of impending threats. The challenge of protecting and managing a park’s natural resources requires a multi-agency, ecosystem approach because most parks are open systems, with threats such as air and water pollution, or invasive species, originating outside of the park’s boundaries. An ecosystem approach is further needed because no single spatial or temporal scale is appropriate for all system components and processes; the appropriate scale for understanding and effectively managing a resource might be at the population, species, community, or landscape level, and in some cases may require a regional, national or international effort to understand and manage the resource. National parks are part of larger ecosystems and must be managed in that context.

Natural resource monitoring provides site-specific information needed to understand and identify change in complex, variable, and imperfectly understood ecosystems and to determine whether observed changes are within historic levels of variability or may indicate human influences. Thus, monitoring data help define the typical limits of variation in park resources and, when put into a landscape context, monitoring provides the basis for determining meaningful change in ecosystems. Monitoring results may also be used to determine what constitutes impairment and to identify the need to initiate or change management practices. Understanding the dynamic nature of park ecosystems and the consequences of human activities is essential for management decision-making aimed to maintain, enhance, or restore the ecological condition of park ecosystems and to avoid, minimize, or mitigate ecological threats to these systems (Roman and Barrett 1999).

The intent of the NPS monitoring program is to track a subset of valued resources and indicators of park ecosystems known as "vital signs." Vital signs, as defined by the NPS for the purposes of the I&M program, are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. Vital signs are part of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," including water, air, geological resources, plants, and animals, and the various ecological, biological, and physical processes that act on these resources. In situations where natural areas have been so highly altered that physical and biological processes no longer operate (e.g., control of fires and floods in developed areas), information obtained through monitoring can help managers understand how to develop the most effective approach to restoration or, in cases where restoration is impossible, ecologically sound management. The broad-based, scientifically-sound information obtained through natural resource monitoring will have multiple applications for management decision-making, research, education, and promoting public understanding of park resources.

B. Legislation, Policy and Guidance

In establishing the first national park in 1872, Congress "dedicated and set apart (nearly 1,000,000 acres of land) as a … pleasuring ground for the benefit and enjoyment of the people" (16 U.S.C. 1 § 21). By 1900, a total of five national parks had been established, along with additional historic sites, scenic rivers, recreation areas, monuments, and other designated units. Each unit was to be administered according to its individual enabling legislation, but had been created with a common purpose of preserving the "precious" resources for people's benefit. Sixteen years later the passage of the National Park Service Organic Act of 1916 (16 U.S.C. 1 § 1) established and defined the mission of the National Park Service, and through it, Congress implied the need to monitor natural resources and guarantee unimpaired park resources:

> "The service thus established shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified … by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, *which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.*"

Congress reaffirmed the declaration of the Organic Act in the General Authorities Act of 1970 (16 U.S.C. 1a-1a8) and effectively ensured that all park units be united into the 'National Park System' by a common purpose of preservation, regardless of title or designation. In 1978, the NPS's protective function was further strengthened when Congress again amended the Organic Act to state "…the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established…" thus further endorsing natural resource goals of each park. More than a decade later, park service management policy again reiterated the importance of this protective function of the NPS to "understand, maintain, restore, and protect the inherent integrity of the natural resources" (National Park Service 2001).

More recent and specific requirements for a program of inventory and monitoring park resources are found in the National Parks Omnibus Management Act of 1998 (P.L. 105-391). The intent of the Act is to create an inventory and monitoring program that may be used "to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources." Subsequently, in 2001, NPS management updated previous policy and specifically directed the service to inventory and monitor natural systems in order to inform park management decisions:

> "Natural systems in the national park system, and the human influences upon them, will be monitored to detect change. The Service will use the results of monitoring and research to understand the detected change and to develop appropriate management actions" (National Park Service 2001).

In addition to the legislation directing the formation and function of the NPS, there are several other pieces of legislation intended to not only protect the natural resources within national parks and other federal lands, but to address general concerns over the environmental quality of life in the United States. Many of these federal laws also require natural resource monitoring within national park units. As NPS units are among some of the most secure areas for numerous threatened, endangered or otherwise compromised natural resources in the country, the particular guidance offered by federal environmental legislation and policy is an important component to the development and administration of a natural resource inventory and monitoring system in the National Parks.

Legislation, policy and executive guidance all have an important and direct bearing on the development and implementation of natural resource monitoring in the National Parks. Relevant federal legal mandates are therefore summarized in Appendix A-1. Of particular importance is the Government Performance and Results Act (GPRA) which is central to NPS operations, including the I&M program. The NPS has developed a national strategic plan identifying key goals to be met (National Park Service 2001). A list of the national GPRA goals relevant to UCBN parks is located in Table 1.3. In addition to the national strategic goals, each park unit has a five-year plan that includes specific park GPRA goals. Many of these park specific goals are directly related to natural resource monitoring needs.

Table 1.3. Government Performance and Results Act (GPRA) goals specific to UCBN parks and relevant to the monitoring plan for the Upper Columbia Basin Network.

| GPRA Goal | Goal # | Parks with this goal |
|---|---|---|
| Natural and cultural resources and associated values are protected, restored, and maintained in good condition and managed within their broader ecosystem and cultural context. | Category Ia | BIHO, CIRO, CRMO, HAFO, JODA, LARO, MIIN, NEPE, WHMI |
| Disturbed lands restored | Ia1A | BIHO, CIRO, CRMO, HAFO, LARO, NEPE, WHMI |
| Exotic vegetation contained | Ia1B | BIHO, CIRO, CRMO, HAFO, JODA, LARO, MIIN, NEPE, WHMI |
| Threatened and Endangered species | Ia2B, Ia2X | JODA, LARO, MIIN |
| Air quality and wilderness values | Ia3 | CRMO |
| Water quality unimpaired | Ia4 | BIHO, CIRO, JODA, LARO, NEPE |
| Cultural landscapes in good condition | Ia7 | BIHO, HAFO, JODA, MIIN, NEPE, WHMI |
| The National Park Service contributes to knowledge about natural and cultural resources and associated values; management decisions about resources and visitors are based on adequate scholarly and scientific information. | Category Ib | BIHO, CIRO, CRMO, HAFO, JODA, LARO, MIIN, NEPE, WHMI |
| Natural resource inventories | Ib1 | BIHO, CIRO, CRMO, HAFO, JODA, NEPE |
| Vital signs for natural resource monitoring identified | Ib3 | BIHO, CIRO, CRMO, HAFO, JODA, LARO, MIIN, NEPE, WHMI |
| Geologic resources inventory | Ib4A | CRMO, HAFO, JODA |
| Geologic resources mitigation and protection | Ib4B | CRMO, HAFO, JODA |
| Aquatic resources | Ib5 | JODA |

## C. Purpose of UCBN Parks

The UCBN includes 3 National Monuments, a National Monument and Preserve, a National Historic Site, a National Historical Park, a National Recreation Area, a National Battlefield, and a National Reserve. In 1970, Congress elaborated on the 1916 NPS Organic Act, saying all of these designations have equal legal standing in the National Park system. Definitions of park designations are found in Appendix A-2.

The enabling legislation of an individual park provides insight into the natural and cultural resources and resource values for which it was created to preserve. Along with national legislation, policy and guidance, a park's enabling legislation provides justification and, in some cases, specific guidance for the direction and emphasis of resource management programs, including inventory and monitoring.

The enabling legislation for several UCBN parks is difficult to interpret because of the legal language used. At least one park, LARO, does not have enabling legislation. The network staff assembled information on the purpose of each park from various park documents, including general management plans, resource management plans, and strategic plans. This does not represent the comprehensive goals and objectives for each park but represents subsets that are most relevant to natural resource monitoring. Park goals and objectives stated in resource management and general management plans are presented in Appendix A-3.

The purpose of designation for UCBN parks varies from preservation of cultural resources to the protection of natural resources. The following five categories encompass the network perspective on the purpose of UCBN parks: 1) interpreting the culture and history of a place or people, such as the Nez Perce tribe, 2) preserving and protecting the uniqueness of an area, such as the geologic resources, the natural quiet, or the paleontological resources, 3) encouraging and supporting scientific research, 4) managing and protecting recreational resources, and 5) preserving and enhancing riparian and wetland areas.

## D. Role of Monitoring

Historically, inventory and monitoring in most parks was subject-specific and primarily driven by the need to deal with specific environmental or management problems. However, over the past decade the NPS has broadened the scope of inventory and monitoring to include all aspects of the ecosystem. The current program is driven as much by the need to fill in gaps in ecological knowledge of the area as by the need to provide information for specific management problems.

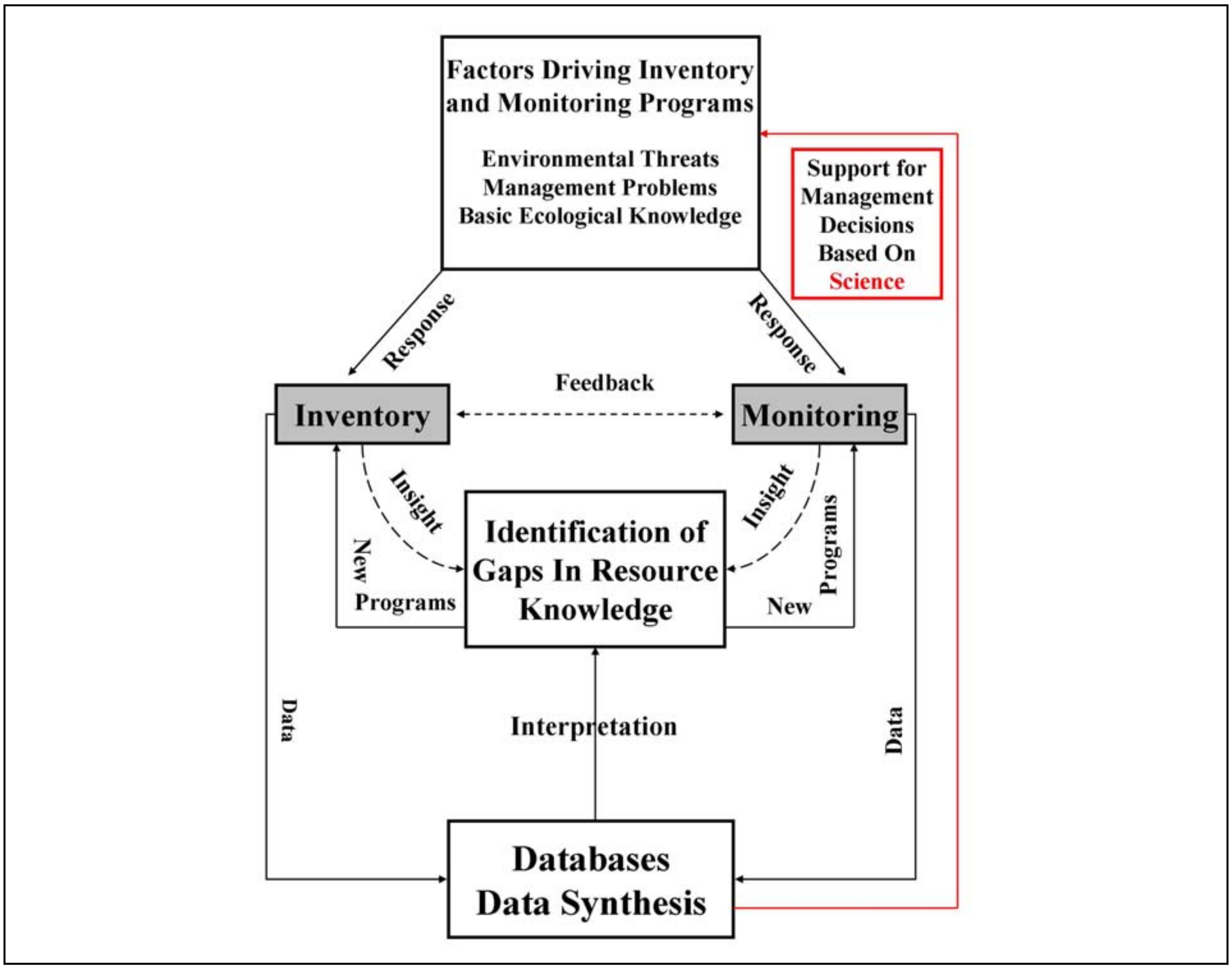
Monitoring is a central component of natural resource stewardship in the NPS and, in conjunction with natural resource inventories and research, provides the information needed for effective, science-based managerial decision-making and resource protection (Figure 1.2). Ecological monitoring establishes reference conditions for natural resources from which future changes can be detected. Over the long term, these "benchmarks" help define the normal limits of natural variation, may become standards with which to compare future changes, provide a basis for judging what constitutes impairment, and help identify the need for corrective management actions.

The overall purpose of natural resource monitoring in parks is to develop scientifically sound information on the current status and long term trends in the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems. Use of monitoring information will increase confidence in manager's decisions and improve their ability to manage park resources. Results from monitoring will allow managers to confront and mitigate threats to the park and operate more effectively in legal and political arenas. To be effective, the monitoring program must be relevant to current management issues as well as anticipate future issues based on current and potential threats to park resources. The program must be scientifically credible, produce data of known quality that are accessible to managers and researchers in a timely manner, and be linked explicitly to management decision-making processes.

The American people expect the NPS to preserve the Nation's heritage, including living and non-living features of ecosystems in all units of the National Park system. Possessing the knowledge of the condition of natural resources in national parks is fundamental to the Service's ability to protect and manage parks. National park managers across the country are confronted with increasingly complex and challenging issues, and managers are increasingly being asked to provide scientifically credible information to defend management actions. The National Parks Omnibus Management Act of 1998 includes a Congressional mandate to provide information on the long-term trends in the condition of National Park system resources.

Management of the national parks is an extremely complicated and difficult task. Many of the threats to park resources, such as invasive species and air and water pollution, originate outside park boundaries and require an ecosystem approach to understand and manage the park's natural resources. Managers must be capable of determining whether the changes they are observing in park ecosystems are the result of natural variability or human activities. If the latter, then resource managers must understand park ecosystem processes and mechanisms well enough to know what actions are needed to restore natural conditions. Such knowledge can only be gained through long-term research and monitoring. Short-term, parochial methods provide a useful beginning but cannot by themselves provide the needed knowledge and understanding. In the words of Ralph Waldo Emerson, “the years teach much which the days will never know.”

Figure 1.2. Information pathways for inventory and monitoring.




## IV. Network Monitoring Goals and Objectives

A. Servicewide Monitoring Goals

As UCBN staff plans, designs, and implements an integrated natural resource monitoring program it is guided by the five NPS servicewide goals in Table 1.4. By adopting the servicewide monitoring goals, certain aspects of the UCBN program scope and direction become apparent. The program will include retrospective or effects-oriented monitoring to detect changes in the status or condition of selected resources, retrospective or stress-oriented monitoring to meet certain legal mandates (e.g., Clean Water Act), and effectiveness monitoring to measure progress toward meeting performance goals (National Research Council 1995, Noon et al. 1999). Through the servicewide goals, the UCBN also acknowledges the need to understand inherent ecosystem variability in order to better detect and interpret human-caused change. It recognizes the potential role of NPS ecosystems as reference sites for more impaired systems and will address these issues of intrinsic variability and reference site comparison through the vital signs selection process and monitoring protocol development.

Table 1.4. NPS servicewide vital signs monitoring goals.

1. Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.

2. Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.

3. Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.

4. Provide data to meet certain legal and congressional mandates related to natural resource protection and visitor enjoyment.

5. Provide a means of measuring progress toward performance goals.

## B. UCBN Monitoring Objectives

The importance of clearly defining the objectives of a monitoring program has been stressed by many authors (Goldsmith 1991, Silsbee and Peterson 1991). Clear objectives help define all aspects of a program including the choice of vital signs to be monitored. The most commonly stated objective for NPS programs is to generate information that will help managers make better informed management decisions (Quinn and Van Riper 1990). This is clearly reflected in the first and second servicewide goals presented above. The objectives of the UCBN monitoring program reflect the network's commitment to this, but also include the ability to document threats or the effects of activities outside of park boundaries. Some authors have suggested that monitoring programs are important simply to document changes just for the sake of familiarity with the resources, to gain insights into how the ecosystem works, or to provide a reference point to which less pristine areas can be compared (Croze 1984, Silsbee and Peterson 1993). The objectives of the UCBN program also reflect this intent. Three broad programmatic monitoring objectives have been identified for the UCBN (adapted from Woodley 1993):

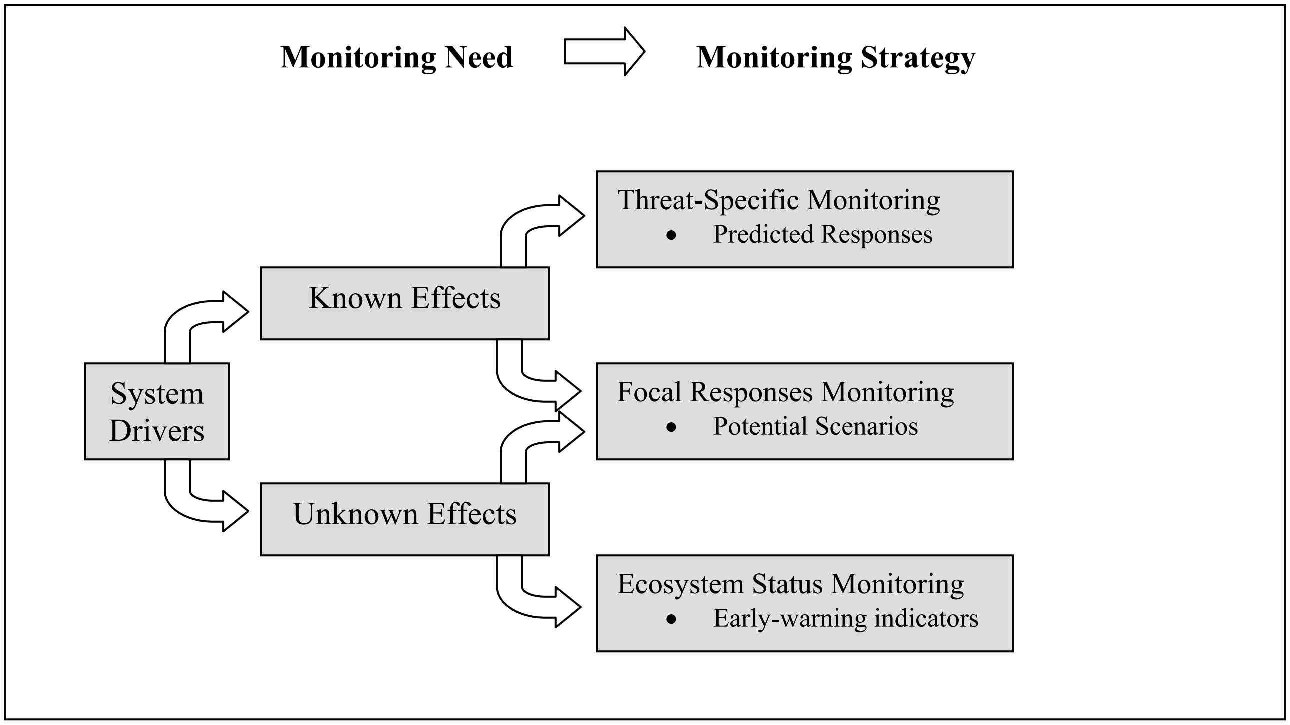
1) Threat-specific Monitoring
- In certain cases where good understanding exists between potential effects and responses by park resources (Known Effects), monitoring of system drivers, stressors, and effected park resources is conducted.

2) Focal Resource Monitoring
- A set of focal resources (including ecological processes) will be monitored to address both known and unknown effects of system drivers and stressors on park resources.

3) Ecosystem Status Monitoring

- Key properties and processes of ecosystem status and integrity will be monitored to improve long-term understanding and potential early warning of undesirable changes in park resources.

Figure 1.3. Three broad programmatic monitoring objectives (adapted from Woodley 1993).




The UCBN selected vital signs for monitoring through a 2-year process that included soliciting input from scientists and park managers through regional workshops, online ranking surveys, and park-level workshops. Conceptual models were used extensively to visually explain linkages between drivers, stressors, and resources identified as important ecologically and of management significance. The process used to determine the “final list” of vital signs was comprehensive and is detailed in Chapter 3 – Vital Signs. The thirteen vital signs selected for monitoring, specific monitoring objectives developed in association with the vital signs, UCBN monitoring objectives, and the conceptual models developed to illustrate key linkages are shown in Table 1.5.

The Network will use existing data collected by other agencies to complete the integrated monitoring program. The compilation of existing data will provide the Network with a well-balanced program at a fraction of the cost. Examples of data that will be compiled from existing sources include ozone, visibility, air contaminants, weather and climate, water chemistry, toxics, aquatic macroinvertebrates, insect pests, and fire and fuel dynamics. Additional details on the compilation vitals signs can be found in Chapter 3 and Table 3.5.

Table 1.5 Selected Vital Signs for Upper Columbia Basin Network with associated vital sign category, conceptual model(s) and monitoring objectives.

| Vital Sign | Vital Sign Category | Conceptual Model(s) | Objectives |
|---|---|---|---|
| Invasive / Exotic Plants | Ecosystem Status | Sagebrush Community Model / Forest Community Model / Riparian Community Model, Cultural Landscape Model | Use monitoring data for early detection and predictive modeling of incipient invasive species. Monitor the status and trend of invasive plants along roads, trails, and other park facilities in the UCBN. |
| Sagebrush-steppe Vegetation | Ecosystem Status | Sagebrush Community Model / Sagebrush Altered Fire Regime Submodel | Determine trends in sagebrush-steppe vegetation composition and structure in the UCBN. |
| Land Cover and Use | Ecosystem Status, Threat-specific | Land Cover / Land Use Model | Document changes in development, land conversion, and succession outside UCBN park boundaries. Determine trends in a suite of landscape metrics including patch shape, size, and connectivity. |
| Riparian Vegetation Communities | Ecosystem Status | Riparian Community Model | Track changes in composition, structure, and landscape pattern of riparian vegetation in the UCBN. |
| Stream / River Channel Characteristics | Ecosystem Status | Lotic Submodel | Track changes in morphology of streambanks and alterations in riparian vegetation in BIHO, JODA, and WHMI. |
| Surface Water Dynamics | Ecosystem Status | Lotic Submodel | Determine the status and trend of surface water quantity, including flow in river and streams in BIHO, JODA, NEPE, and WHMI. |
| Water Quality - Macroinvertebrates | Ecosystem Status | Lotic Submodel | Determine the status and track changes in the species and functional group composition and abundance of aquatic macroinvertebrates in BIHO, CIRO, JODA, NEPE, and WHMI. |
| Aspen | Focal resource | Aspen Altered Fire Regime Submodel | Monitor trends in recruitment and mortality and track changes in composition, structure, and landscape pattern of aspen vegetation in CIRO and CRMO. |
| Osprey | Threat-specific | Osprey Submodel, Lotic Submodel Lentic Submodel | Provide baseline data on the size and composition of the local osprey population, document annual fluctuations within this population and determine annual nesting trends, nesting productivity (fledges per nest) and nesting success by nest structure and location. |
| Bats | Focal resource | Bat Community Submodel | Track spatial-temporal patterns of bat species presence and activity along important riparian foraging areas in CIRO, CRMO, and JODA. Conduct periodic maternity roost exit counts in JODA and CRMO to monitor trends in abundance of sensitive colonial species. |
| Limber Pine | Focal resource | Limber Pine Submodel | Monitor limber pine stands in CRMO for early detection and increase of white pine blister rust and needle cast infection. |
| Camas | Focal resource | Cultural Landscape Model, Camas Lily Submodel | Track changes in the areal extent and density of camas in relation to invasive plants and land use practices in NEPE and BIHO. |
| Sage Grouse | Focal resource | Sagebrush Community Model, Sage Grouse Submodel | Determine trends in populations of sage grouse at CIRO and CRMO. |

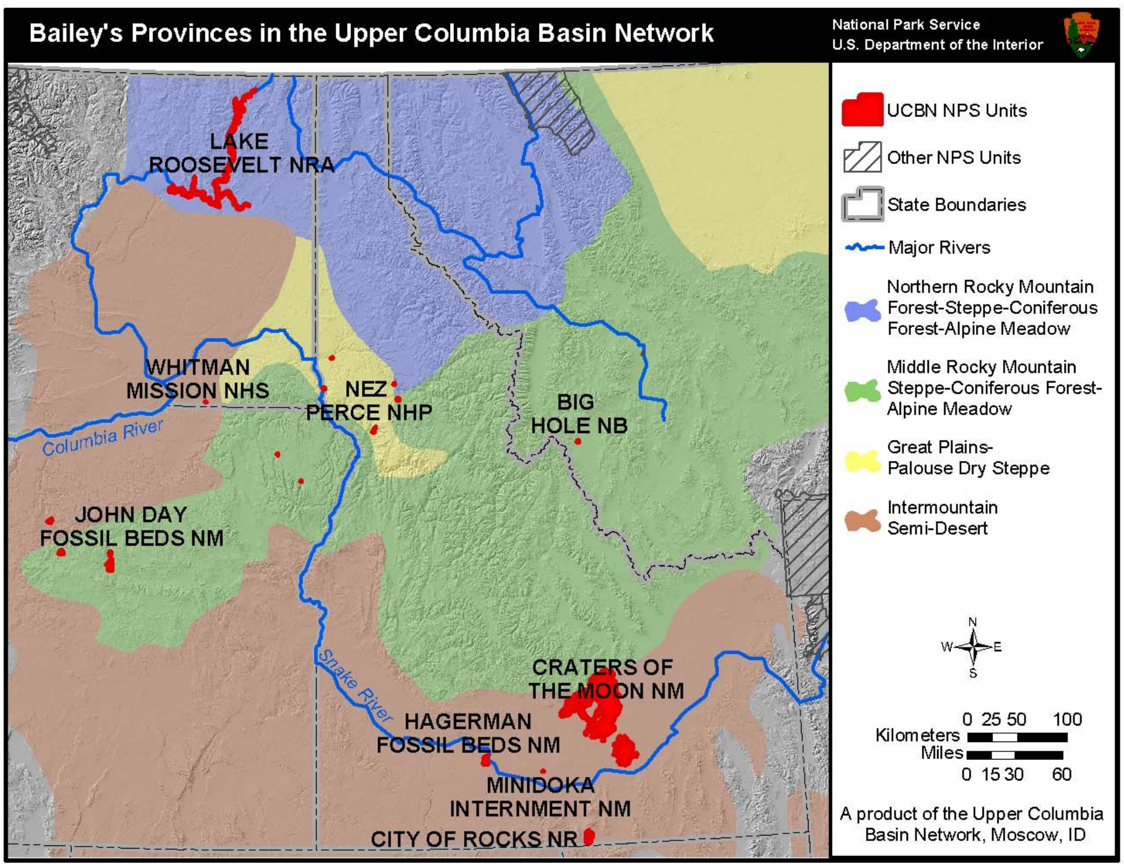
## V. Ecological Context

A. UCBN Parks and Resources

The nine parks in the UCBN are spread across four states and occupy portions of the Columbia Plateau and Snake River Plain geographic regions. All parks are located within the Columbia River Basin except BIHO and the Bear Paw Battlefield unit of NEPE. UCBN park units include a total of over 245,000 hectares of land area, span 850 kilometers from east to west, 765 kilometers from north to south, and cover 2506 meters of vertical relief. The lands contained in the UCBN are highly diverse.

The network adopted a land classification system to better understand the similarities and relationships among park units. The idea of ecoregions emerged as the most useful land classification system for supporting sustainable resource management practices (Bailey 1995, 1998). The ecosystem concept underlies the ecoregion system of land classification because it effectively brings together the biological and physical worlds into a framework by which natural systems can be described, evaluated, and managed (Rowe 1992).

Figure 1.4. Bailey's Ecoregion Provinces in the UCBN.



The Columbia basin is in a transition-type climate zone and climate patterns are dominated by topographic features (Ferguson 1999, Quigley and Arbelbide 1997). Vegetation type and distribution varies depending on the soils, long-term precipitation patterns, and climate. Climate at park sites is influenced by three distinct air masses: 1) moist, marine air from the west that moderates seasonal temperatures; 2) continental air from the east and south, which is dry and cold in winter and hot with convective storms in summer; and 3) dry, arctic air from the north that brings cold air to the basin in winter and helps to cool the basin in summer (Ferguson 1999).

Most precipitation accumulates during winter (20-40 cm, 8-16 inches) in the central Columbia and Snake River Plateaus. The mountain snowpack acts as a natural reservoir and supplies the basin with most of its useable water. Summer precipitation through the basin ranges from about 20-50 cm (8-20 inches). Trends in the last 50 to 100 years indicate a general decrease in winter precipitation and increase in summer precipitation (Ferguson 1999).

Temperatures are generally mild in the basin because of the periodic influxes of moderating Pacific moisture. Winter mean monthly temperatures range from -10 to -3°C (-50 to 27°F) and summer temperatures ranges from 10 to 15°C (50 to 59°F). Trends in the last 50 to 100 years indicate a slight increase in winter temperatures and slight decrease in summer temperatures (Ferguson 1999). Climate change scenarios identified by the US Global Change Research Program (USGCRP) for the Rocky Mountain/Great Basin region, which includes the UCBN area, are complex but include a reduction in snowpack and an overall aridifaction of the region, with increased evapotranspiration negating the effects of potential increased summer precipitation (Wagner et al. 2003).

UCBN parks contain hundreds of soils that vary widely in their age and parent material, occur across a range of climatic conditions and topography, and support a wide variety of vegetation types. This variation results in a broad range of productivity. Soils descriptions are grouped by the province in which a park occurs and can be found in Appendix B-3.

The Columbia Plateau is the most significant geologic province of the UCBN and its unique volcanic geology dominates much of the present day landscape in the UCBN. The plateau contains one of the world's largest accumulations of lava. Over 170,000 cubic kilometers of basaltic lava, known as the Columbia River basalts, covers the western part of the province. Following this period of intense volcanism were the repeat events of glaciation during the Pleistocene Epoch that reshaped much of the Columbia Plateau. Continental ice sheets reached as far south as the Spokane area in eastern Washington, and montane glaciers reached farther south down the Rocky Mountain and Cascade chains. Massive pluvial lakes and ice dams drove repeated flood events that continue to have a tremendous effect on modern day geomorphology as well as land use practices.

Big Hole NB and the northern portion of Lake Roosevelt NRA are considered within the Rocky Mountain geologic province. Both the Big Hole valley and the Okanagan Highlands of upper Lake Roosevelt have experienced extensive reshaping from Pleistocene glaciation. Beginning about 2.5 million years ago and lasting until about 10,000 years ago, lobes of continental and cordilleran ice sheets ground across the Northern Rockies and the northern edge of the Columbia Plateau. The Big Hole valley itself is a broad "U"-shaped valley carved by glaciers and the

Okanagan Highlands were repeatedly smoothed over from periodic glacier movements. (Additional information on geoclimatic characteristics and descriptions of geologic sections of the Columbia Plateau can be found in Appendices B-4 and B-5, respectively.)

Shrub-steppe habitat is the most extensive vegetation type in the Upper Columbia Basin Network parks (Table 1.6). However, forested vegetation is also widespread, especially in the northern portion of the network. Forest types present in the network include ponderosa pine forest, pinyon-juniper woodlands, lodgepole pine forest, aspen communities, isolated stands of Douglas-fir, and limber pine woodland. Small amounts of wetland and riparian vegetation are also present in most UCBN parks. Descriptions of major vegetation types within the Network can be found in Appendix B-6 and are discussed at length in Appendix C.

Table 1.6. Percentage of UCBN park area in each land cover type as determined with the National Land Cover Dataset and the National Park Service digital park unit layer (NPS boundary)

| Land Cover | BIHO | CIRO | CRMO | HAFO | JODA | LARO | MIIN | NEPE | WHMI |
|---|---|---|---|---|---|---|---|---|---|
| Open Water | 1% | | | 1% | 1% | 75% | | 1% | 6% |
| Urban | | | <1% | | | 1% | | <1% | |
| Bare Rock/Sand/Clay | | | 81% | <1% | 1% | <1% | | | |
| Transitional | 18% | | | | | <1% | | 4% | <1% |
| Deciduous Forest | <1% | <1% | | | <1% | <1% | | 4% | 2% |
| Evergreen Forest | 23% | 4% | | <1% | 21% | 11% | | 7% | |
| Mixed Forest | | | | | | <1% | | <1% | |
| Shrubland | 3% | 71% | 18% | 53% | 68% | 6% | 45% | 17% | 3% |
| Orchards/Vineyards/Other | | | | | | <1% | | | 5% |
| Grasslands/Herbaceous | 32% | 23% | 1% | 41% | 5% | 4% | 29% | 51% | 83% |
| Agriculture | | 3% | <1% | 5% | 5% | 1% | 26% | 16% | |
| Woody Wetlands | 21% | <1% | <1% | <1% | | <1% | <1% | <1% | |
| Emergent Herbaceous Wetlands | 2% | | | | <1% | <1% | | <1% | |

Vertebrate communities associated with upper Columbia Basin habitats are well represented in UCBN parks. The fauna present vary widely from site to site due to presence or absence of refugia, type of vegetation communities, and the presence or absence of water. Over 300 terrestrial vertebrate species were identified during the 2000-2003 inventories in the UCBN parks, including 24 species of reptiles and amphibians, 76 species of mammals, and over 200 species of birds. Current estimates, based on existing information, indicate that approximately 15-20 species of fish are also present in network waters. The bald eagle, bull trout, and summer steelhead (Middle Columbia Evolutionary Significant Unit) are the only confirmed vertebrate species listed as threatened or endangered under the Endangered Species Act in the UCBN (see Appendix D-4.). However, many vertebrates that occur in UCBN parks are listed as state and / or federal species of concern, and many are unique to the semi-arid habitats of the upper Columbia Basin. This list includes unique species such as the greater sage grouse, pygmy rabbit, spotted bat, Columbia spotted frog, and western toad. One of the last strongholds of the arctic grayling south of Canada and Alaska is in the upper reaches of the Big Hole and North Fork Big Hole Rivers (Additional information on UCBN fauna can be found in Appendix B-7).

B. Air quality monitoring within the Upper Columbia Basin Network

While air quality monitoring stations are located near several UCBN parks (Table 1.7), the only park unit that has air quality monitoring onsite and is considered a Class I airshed is Craters of the Moon NM. The designation of Craters of the Moon NM as a Class I airshed under the Clean Air Act, requires that the airshed receives the highest level of air quality protection. Consequently, CRMO participates in the NPS's comprehensive air resources management program, designed to assess air pollution impacts and protect air quality related resources. The NPS operates monitoring instruments near the Monument's Visitor Center, which record concentrations of ozone, fine particles which affect visibility, and acid precipitation. These sites are part of national monitoring networks which record existing conditions, detect trends, and help in the development of predictive models for air quality used throughout the country.

There are fifteen National Atmospheric Deposition Program (NADP) sites within 300 km of UCBN parks. The purpose of the NADP network is to collect data on the chemistry of precipitation for monitoring of geographical and temporal long-term trends. The precipitation at each station is collected weekly according to strict clean-handling procedures. It is then sent to the Central Analytical Laboratory where it is analyzed for hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and base cations (such as calcium, magnesium, potassium and sodium). Table 1.7 lists only the closest NADP sites to each park.

The National Park Service (NPS) and other Federal Land Managers are required by the Clean Air Act to protect visibility at Class I areas, which include most national parks and wilderness areas. There are twelve monitoring sites that are operated by the Interagency Monitoring of Protected Visual Environments Program (IMPROVE) within 300 km of UCBN parks. The IMPROVE program includes the characterization of haze by photography, the measurement of optical extinction with transmissometers and nephelometers, and the measurement of the composition and concentration of the fine particles that produce the extinction and the tracers that identify emission sources.

Under provisions of the Clean Air Act, which is intended to improve the quality of the air we breathe, EPA sets limits on how much of a pollutant can be in the air anywhere in the United States. AirData has annual summaries of the air pollution measurements for the current and ten previous years. The AQS database is updated nearly every day by states and local environmental agencies that operate the monitoring stations. The states provide this monitoring data as required by the Clean Air Act. There are four Aerometric Information Retrieval System (AIRS) sites within 300 km of UCBN parks. The only park site to have an Air Quality Station onsite is Craters of the Moon NM.

Table 1.7. Distance (km) of National Atmospheric Deposition Program (NADP), Interagency Monitoring of Protected Visual Environments Program (IMPROVE), and Aerometric Information Retrieval System (AIRS) air quality monitoring stations from UCBN parks.

| Type | SiteCode | BIHO | CIRO | CRMO | HAFO | JODA | LARO | MIIN | NEPE | WHMI |
|---|---|---|---|---|---|---|---|---|---|---|
| NADP | ID03 | | 50-150 | Onsite | 50-150 | | | 50-150 | | |
| NADP | ID04 | | | | | | | | < 50 | |
| NADP | MT97 | < 50 | | | | | | | | |
| NADP | OR17 | | | | | 50-150 | | | | < 50 |
| NADP | OR18 | | | | | 50-150 | | | | |
| NADP | WA15 | | | | | | < 50 | | | |
| NADP | WA24 | | | | | | | | < 50 | |
| | | | | | | | | | | |
| IMPROVE | CRMO | | | Onsite | 50-150 | | | 50-150 | | |
| IMPROVE | CORI | | | | | 50-150 | | | | |
| IMPROVE | HECA | | | | | | | | < 50 | |
| IMPROVE | JARB | | 50-150 | | | | | 50-150 | | |
| IMPROVE | MONT | | | | | | | | | |
| IMPROVE | PASA | | | | | | 50-150 | | | |
| IMPROVE | STAR | | | | | 50-150 | | | | 50-150 |
| IMPROVE | SULA | < 50 | | | | | | | | |
| | | | | | | | | | | |
| AIRS | 320 | 150-300 | 150-300 | Onsite | 50-150 | | | 50-150 | | |
| AIRS | 938 | | | | | 50-150 | | | 150-300 | 150-300 |
| AIRS | 939 | | | | | | | | | 150-300 |
| AIRS | 944 | | | | | | < 50 | | 150-300 | 150-300 |

The Air Resources Division (ARD) of the NPS released a report detailing a risk assessment for parks in the UCBN (MIIN was not a NPS site at the time of this assessment and is not included)(Air Resources Division 2001). This report describes the risk of foliar injury at each park and explains threshold values for ozone measurements. All parks in the UCBN, with the exception of City of Rocks NR were rated as low for ozone risk (Table 1.8). The risk of foliar ozone injury at City of Rocks National Reserve is moderate. The risk of injury is greatest in years when the ambient level of ozone is high, and soil moisture conditions favor uptake by plants. The ARD advised that quaking aspen and Scouler's willow could be used as bioindicator species to assess foliar injury at CIRO.

Table 1.8 Summary of ozone risk assessments for parks in the UCBN.

| Park | Ozone Risk | O3 Data Acquired |
|---|---|---|
| Big Hole NB | Low | kriged |
| City of Rocks NR | Moderate | kriged |
| Craters of the Moon NM | Low | monitored onsite |
| Hagerman Fossil Beds NM | Low | kriged |
| John Day Fossil Beds NM | Low | kriged |
| Lake Roosevelt NRA | Low | kriged |
| Nez Perce NHP | Low | kriged |
| Whitman Mission NHS | Low | kriged |

C. Water quality monitoring within the Upper Columbia Basin Network

The Water Resources Division (WRD) of the NPS provides a separate source of funding each fiscal year to the UCBN to accomplish water quality monitoring. It was decided by the Network Board of Directors and Science Advisory Committee that water quality monitoring for the UCBN will be accomplished as an integrated program with other Network monitoring. The Network received its first year of funding in 2005 and has a cooperative agreement with Dr. Chris Caudill at the University of Idaho to compile and summarize all existing water quality information for Network parks and to develop a comprehensive water quality monitoring plan during fiscal year 2006. Vital signs related to water quality are discussed in more detail in Chapter 3. Aquatic resource vital signs include surface flow regimes, water chemistry, toxic pollutants and aquatic macroinvertebrates.

Aquatic resources represent a very small percentage of total land cover in UCBN parks, except in the case of Lake Roosevelt NRA (see Table 1.6). However, like riparian and wetland vegetation, aquatic environments are disproportionately important in terms of biodiversity, biological productivity, and many other ecosystem functions and values (Richardson 1994, Kauffman et al. 1997, McKinstry et al. 2004). Lotic (flowing water) environments in the UCBN include large rivers, perennial tributary creeks, irrigation ditches, and numerous seasonal and ephemeral streams, springs, and seeps. Lake Roosevelt, a large run-of-the-river reservoir in the Columbia River, and Lower Salmon Falls Reservoir in the Snake River adjacent to HAFO, function as lotic environments in the upper reaches of the reservoir and lentic environments near the dam. Impoundments on Columbia Basin rivers provide both lotic and lentic environments along longitudinal gradients. Other lentic environments in the UCBN include small lakes and ponds, as well as floodplain and depressional wetlands. Table 1.9 presents the distribution of aquatic environments in the UCBN.

Table 1.9. Aquatic Resources of UCBN Parks.

| Park | Large Rivers (no.) | Small Rivers & Streams (no.) | Intermittent Streams (no.) | Irrigation Ditches (no.) | Ponds (no.) | Reservoir (no.) | Mapped Springs / Seeps (no.) | Unmapped Springs / Seeps (no.) |
|---|---|---|---|---|---|---|---|---|
| BIHO | 1 | 1 | | 2 | | | | |
| CIRO | 5 | 5 | numerous | | | | 5 | 1+ |
| CRMO | 1 | 1 | | | 1 | | 9 | numerous |
| HAFO | | | | 1 | | 1 | 1+ | numerous |
| JODA | 1 | 2 | 1 | 2 | 1 | | 8 | 6 |
| LARO | 1 | 5 | | | | 1 | | |
| MIIN | | | | | | | | |
| NEPE | 2 | 1 | | | 1 | | | |
| WHMI | | 2 | | 1 | 1 | | | |

The variability in climatic and geologic processes within the upper Columbia Basin has resulted in a complex diversity of aquatic habitats. Aquatic habitat heterogeneity is important to biological diversity in both terrestrial and aquatic environments (Gresswell et al 1994, Schlosser 1991). This is especially true in the semi-arid environment of the upper Columbia Basin, and aquatic environments, including the riparian/wetland vegetation “greenline” zone, provide three-dimensional connectivity between the atmosphere, uplands, and upstream/downstream reaches

(Gregory et al. 1991). The maintenance of aquatic habitat complexity is critical for biodiversity within the context of increasing human-driven disturbances. Although climatic and geologic processes cannot be managed, human response to them can be planned, and in some cases, human disturbances might be modified to maintain desired habitat complexity in the context of natural disturbance regimes (Reeves et al. 1995).

Activities throughout watersheds may affect ecosystem processes and water quality (Allan 2004), necessitating a watershed approach for effective management. However, individual watersheds typically contain a large number of owners, land uses and overlapping regulatory jurisdictions. Consequently, effective management of aquatic resources becomes increasingly complicated as the water body size and associated watershed increases. This is true within the UCBN park units, where water bodies loosely fall into three general categories. Many water bodies within the UCBN are small streams, seeps, or ponds with relatively small watersheds that may be partly or wholly contained with the park unit. These resources have no or few available data on water quality or aquatic biota. In contrast, three park units (JODA, NEPE, HAFO) include portions of three free-flowing or impounded large rivers—the John Day, Clearwater, and Snake Rivers—that have watersheds extending thousands of square kilometers upstream of park units, and have or have had substantial aquatic resource monitoring. Lake Roosevelt is unique within the network because the recreation area includes a large proportion of the reservoir shoreline. Impairments of aquatic resources by upstream inputs, particularly toxic pollutants from a lead-zinc smelter in Trail, British Columbia operated by Cominco, Inc. and past and current mining activities in the Coeur d'Alene drainage basin have had cascading effects on lake sediments and effects on human health are now being investigated. Lake Roosevelt is currently being considered for listing as an EPA "Superfund" site. Consequently, we plan to focus UCBN water quality monitoring resources on LARO tributaries rather than Lake Roosevelt itself.

Our approach to water quality monitoring will reflect these differences. We propose to focus resources in the small water bodies within the network because these aquatic resources likely hold biotas which rely largely or completely on habitats within park units. In contrast to large river biota, the smaller water bodies and associated resources should respond more strongly to management and restoration action. These habitats will provide valuable monitoring sites for the detection of invasive species and help fill a water quality data gap compared to available data for large river systems and Lake Roosevelt.

Assessments of aquatic resources in the Columbia Basin have shown wide-spread habitat degradation, and have identified habitat degradation as a major factor, along with dams, excessive harvest, and introduced non-native gamefish, in the declining fisheries throughout the basin (National Research Council 1996, Quigley and Arbelbide 1997, Levin et al. 2002). Extensive grazing caused removal of willow riparian vegetation in many parts of the region as early as 1860 (Elmore and Kauffman 1994). Floodplain irrigation and agriculture altered hydrology and many river and stream channels were straightened and cleaned of wood and other in-stream structures (Quigley and Arbelbide 1997). Beginning in the early 20th century, large dams were constructed along many rivers and streams in the basin for flood control, irrigation, and electricity, resulting in habitat loss, degradation, and altered hydrology. This legacy of habitat alteration is clearly evident in most UCBN aquatic environments. Lake Roosevelt, the Snake River adjacent to HAFO, the Walla Walla River and Mill Creek at WHMI, the Clearwater

River adjacent to NEPE, the North Fork Big Hole River at BIHO, and the John Day River at JODA have all experienced much of the significant habitat loss, degradation, and associated declines in native fish populations that have occurred throughout the Columbia Basin (National Research Council 1996, Quigley and Arbelbide 1997). Water quality impairment in the Columbia Basin is also widespread, primarily as a result of non-point source pollution (Quigley and Arbelbide 1997). Water temperature, turbidity and sedimentation, nutrients, and streamflow alteration have been identified as the most proximal causes of impairment (Quigley and Arbelbide 1997). Again, specific cases of point-source discharge of pollutants are also numerous, and Lake Roosevelt itself has high levels of toxic industrial waste buried in sediments that originated upstream.

In 2003, a water quality questionnaire was sent to resource managers in UCBN parks to assess the threats to water quality in their parks. A summary of these threats is shown in Table 1.10. Information on water resources within the UCBN parks is limited. The Network is in the process of completing a thorough assessment of past water quality monitoring efforts in Network parks and identifying potential sites for future monitoring efforts. HAFO has completed a water resources management plan (Farmer and Riedel 2003) and LARO has completed a water resources scoping report (Riedel 1997). All of the parks, except MIIN, have Level I baseline water quality data reports ("Horizon" reports) completed by NPS Water Resources Division (WRD). Currently, the majority of UCBN parks do not collect water quality monitoring data, although some parks have state DEQ monitoring sites located nearby. There are no designated Outstanding Natural Resource Waters (ONRW) or watersheds of exceptional quality identified in the UCBN.

All UCBN waters assessed by state Division of Environmental Quality (DEQ) agencies are on 303(d) lists for impairment of at least one parameter. Table 1.11 lists the impairments for each UCBN park. In the case of the North Fork Big Hole River, Montana DEQ identifies agricultural crop related sources for impairment in its 2002 303(d) list. Flow impairment is threatening the arctic grayling population in the Big Hole drainage. Information for HAFO from both Idaho DEQ and Farmer and Riedel (2003) indicate significant water quality stressors originating from extensive agricultural irrigation. The fossil-bearing bluffs in HAFO have experienced a series of large landslides beginning in 1979 resulting from perched aquifers formed from irrigation to the crop fields above the escarpment. Although pesticides and industrial chemicals are not listed on the 303(d) list for Lower Salmon Falls Reservoir, sturgeon tissue samples collected immediately below the reservoir have shown organochlorine and PCB levels exceeding maximum contaminant levels set by the EPA (Farmer and Riedel 2003). In the case of JODA, Oregon DEQ water quality index reports for the John Day Basin show fair to poor water quality both above and below the monument, one monitoring site near Dayville above the Sheep Rock Unit is showing improving water quality, and one at the confluence of the North Fork John Day River downstream from Sheep Rock shows declining quality. Average water quality index scores are poor for the mainstem John Day

Table 1.10. Summary of threats to water resources in the UCBN.

| Park | State | Data | Threats to Water Resources |
|---|---|---|---|
| Big Hole National Battlefield (BIHO) | MT | Park data - none Outside sources from 1975 | Mining, agriculture, and stormwater runoff |
| City of Rocks National Reserve (CIRO) | ID | Park – no data since 1985 | Ranching and grazing activities; residential development; gas, oil and mining operations; recreational use |
| Craters of the Moon National Monument (CRMO | ID | 1999-2003 | Pesticide runoff and drift from agricultural lands, as well as weed management activities along state and county roads |
| Hagerman Fossil Beds National Monument (HAFO) | ID | 2003 | Irrigation and agricultural activities, altered subsurface hydrology, upstream agricultural and industrial effluent, altered flow regulation |
| John Day Fossil Beds National Monument (JODA) | OR | 2003 | Irrigation withdrawals and confined animal feeding upstream, untreated sewage effluent upstream |
| Lake Roosevelt National Recreation Area (LARO) | WA | 2002-2003 | Mining, permitted discharges from waste water treatment plants, residential development (septic tanks), and agriculture (grazing and farming), campsite sewage disposal, upstream industrial discharge, altered flow regulation |
| Minidoka Internment National Monument (MIIN) | ID | No Data | No water resources within the park boundaries |
| Nez Perce National Historical Park (NEPE) | ID | 1975-1994 | Point and non-point discharge from upstream sources – Dworshak dam, agriculture, logging, grazing, recreation, highway runoff and urbanization |
| Whitman Mission National Historic Site (WHMI) | WA | 2000-2003 | Agricultural chemical use, over allocation of irrigation water, private airfield 3 miles upstream |

during summer due to low flow and increased concentrations of fecal coliform, elevated temperature, and reduced dissolved oxygen. In the case of Lake Roosevelt, serious concerns have been raised about the high levels of sediment contamination resulting from over 70 years of industrial discharge originating in Canada. In NEPE, the reach of the Clearwater adjacent to the Spalding Unit of NEPE and Lapwai Creek which flows through Spalding show impacts from upstream agriculture, highway runoff, and other land use practices. The reach of Jim Ford Creek through Weippe Prairie has not been assessed by Idaho DEQ but it has been severely degraded by historic channel straightening and intensive agricultural and grazing activities and water quality is almost certainly impaired there as well. Along Mill Creek and the Walla Walla River at WHMI, temperature, instream flow, and fish habitat are all impaired parameters. Impacts from agriculture throughout the Walla Walla Valley are of concern, and lower reaches of the Walla Walla River downstream of WHMI are on the Washington DEQ 303(d) list for chlordane, benzene, dieldrin, heptachlor, and total PCB’s.

Table 1.11. The current 303(d) listings for waters in the UCBN.

| Park | 303(d) listed waters | Impairments | List Date |
|---|---|---|---|
| Big Hole National Battlefield (BIHO) | N. Fork Big Hole River | Flow Impairment, Dewatering | 2002 |
| City of Rocks National Reserve (CIRO) | Not Assessed | | |
| Craters of the Moon National Monument (CRMO | Not Assessed | | |
| Hagerman Fossil Beds National Monument (HAFO) | Lower Salmon Falls Reservoir (Snake R.) | Dissolved Oxygen (DO), Flow Alteration, Sediment | 2000 |
| John Day Fossil Beds National Monument (JODA) | John Day River, Pine Creek, Bridge Creek, Rock Creek | Temperature, Dissolved Oxygen (DO), Fecal Coliform | 2002 |
| Lake Roosevelt National Recreation Area (LARO) | Lake Roosevelt, Colville River, Spokane River, Colville River | Sediments, Fecal Coliform, Total PCB's, Mercury, Lead, Zinc, Cadmium, Copper, Dioxin, Arsenic, AROCLOR 1254, DDT, Dieldrin, Total Dissolved Gas | 2002 |
| Minidoka Internment National Monument (MIIN) | Not Assessed | | |
| Nez Perce National Historical Park (NEPE) | Lower Clearwater River, Lapwai Creek | Total Dissolved Gas, Nutrients, Bacteria, Dissolved $O_2$ (DO), Flow Alteration, Habitat Alteration, Sediment, Temperature | 2002 |
| Whitman Mission National Historic Site (WHMI) | Mill Creek, Walla Walla River | Temperature, Instream Flow, Fish Habitat | 2002 |

Beyond the 303d listings, very few data are available to assess the status or trends of water quality within UCBN park boundaries. Few of the sampling sites compiled by the 1997 Baseline Water Quality Data Inventory and Analysis reports were within park boundaries (Table 1.12). Similarly, few data or no data have been submitted to STORET since the 1997 reports for most UCBN units (Table 1.13).

Table 1.12: Summary of sampling stations and sampling from the 1997 Baseline Water Quality Data Inventory and Analysis reports.

| Park | Total Stations | Number in Park | %Stations in Park | % All Reported Observation that were in Park |
|---|---|---|---|---|
| BIHO | 18 | 0 | 0.0% | 0.0% |
| CIRO | 12 | 3 | 25.0% | 21.9% |
| CRMO | 23 | 10 | 43.5% | 65.8% |
| HAFO | 66 | 4 | 6.1% | 0.3% |
| JODA | 42 | 4 | 9.5% | 2.3% |
| NEPE | 238 | 0 | 0.0% | 0.0% |
| WHMI | 20 | 9 | 45.0% | 35.3% |

During the vital sign prioritization process the UCBN identified the sampling of water bodies within park units for macroinvertebrate community structure as the top water quality monitoring priority, followed by the characterization of channel morphology and in-stream habitat, and baseline sampling of water chemistry parameters as secondary priorities. The status of each body will be assessed using well developed indices of invertebrate community structure that indicate relative water quality compared to reference or unimpaired water bodies within a region (EPA et al. 1999). EPA and state guidelines will be used to determine if water chemistry parameters exceed threshold indicating impaired water quality.

A baseline survey of macroinvertebrates will provide a cost-effective baseline sampling of water quality designed to both identify park water bodies with impaired water quality and provide baseline data on community structure and composition for an important aquatic resource Vital Sign. The latter will both inventory park faunal resources and provide baseline data for the monitoring of invasive species. Anticipated fiscal resources should allow annual sampling of a portion of UCBN units, with each unit sampled on a 2-3 year rotation. Details of the sample plan will be presented in the Phase III report.

Table 1.13: Number of available water quality observations by category and sampling period for data reported in 1997. Baseline reports and downloaded from STORET, May, 2005. Data include all sites in 1997 Baseline report study areas.

| Park | Sampling Period | Alkalinity | pH | Conductivity | Dissolved Oxygen | Temperature | Flow | Turbidity | Nitrate/ Nitrogen | Phosphate Phosphorus | Chlorophyll | Sulfates | Bacteria | Toxic Elements |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BIHO | pre 1984 | 174 | 91 | 146 | 78 | 107 | 142 | 89 | 23 | 17 | 0 | 109 | 4 | 43 |
| | 1985-1996 | 0 | 0 | 13 | 0 | 12 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1997-2004 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 8 | 4 | 0 | 12 | 0 | 80 |
| | | | | | | | | | | | | | | |
| CIRO | pre 1984 | 23 | 14 | 14 | 0 | 11 | 4 | 0 | 1 | 1 | 0 | 7 | 0 | 0 |
| | 1985-1996 | 3 | 2 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| | 1997-2004 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| CRMO | pre 1984 | 13 | 180 | 171 | 165 | 180 | 1 | 74 | 412 | 142 | 92 | 3 | 80 | 134 |
| | 1985-1996 | 0 | 169 | 160 | 165 | 169 | 0 | 74 | 411 | 137 | 92 | 0 | 80 | 104 |
| | 1997-2004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | | |
| HAFO | pre 1984 | 666 | 749 | 724 | 386 | 678 | 562 | 753 | 1566 | 964 | 8 | 683 | 626 | 970 |
| | 1985-1996 | 102 | 127 | 174 | 128 | 162 | 141 | 312 | 560 | 309 | 0 | 120 | 108 | 28 |
| | 1997-2004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | | |
| JODA | pre 1984 | 278 | 1271 | 1342 | 2330 | 5960 | 439 | 1159 | 1678 | 1076 | 273 | 425 | 804 | 290 |
| | 1985-1996 | 133 | 838 | 884 | 1705 | 5554 | 68 | 652 | 989 | 629 | 181 | 84 | 339 | 39 |
| | 1997-2004 | 0 | 16 | 14 | 15 | 16 | 0 | 32 | 16 | 0 | 0 | 14 | 47 | 0 |
| | | | | | | | | | | | | | | |
| NEPE | pre 1984 | 2287 | 3185 | 3087 | 2367 | 3557 | 3243 | 2754 | 6283 | 3705 | 89 | 3052 | 2299 | 6480 |
| | 1985-1996 | 361 | 813 | 1061 | 589 | 1168 | 774 | 466 | 2659 | 1497 | 71 | 455 | 517 | 856 |
| | 1997-2004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | | |
| WHMI | pre 1984 | 563 | 352 | 352 | 384 | 404 | 314 | 352 | 902 | 735 | 0 | 547 | 553 | 326 |
| | 1985-1996 | 10 | 10 | 10 | 12 | 0 | 0 | 0 | 20 | 10 | 0 | 20 | 0 | 96 |
| | 1997-2004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## D. Cultural Landscapes

The upper Columbia Basin has a rich and fascinating cultural history. This is the land of a highly diverse human landscape, in which many linguistic and cultural traditions sprang up around the great salmon fisheries, wild root crops, and other natural resources of the region. The Nez Perce (Nimiipuu), Cayuse, Wasco, Yakima, Paiute, Shoshone, and their ancestors have lived in the region for thousands of years and have made an indelible imprint on the landscape. The Columbia Basin was also a central stage in the inexorable and tragic displacement of Native Americans by pioneering European Americans that occurred throughout the west during the 19$^{th}$ century. Beginning with the first encounter between Lewis and Clark's Corps of Discovery and the Nez Perce at Weippe Prairie in NEPE, this period of cultural schism is also remembered in the landscapes of Whitman Mission, Ft. Spokane at LARO, and the many battlefields of the Nez Perce Trail where the Wallowa Band was led on a 1300-mile exodus from Oregon to northcentral Montana under pursuit by the U.S. Cavalry. Overlaid upon this historical period has been the formation of modern American cultural landscapes during the 20$^{th}$ century, such as the rural agricultural landscape of the Cant Ranch along the John Day River, the Minidoka Internment Center of World War II, and the creation of Franklin D. Roosevelt Lake behind the Grand Coulee Dam. Today thousands of visitors come to see and recreate in these landscapes, preserved and memorialized in UCBN parks. Nez Perce tribal members hold an annual memorial event at the Big Hole Battlefield and rock climbers come from around the world to challenge themselves on the unique formations of the City of Rocks.

Cultural landscapes are an important component of the parks of the UCBN. While cultural landscapes represent a relatively small proportion of total land area in the network, they are disproportionately important to park mission and visitor experience. Cultural landscapes in the network include historic sites, historic vernacular landscapes, and ethnographic landscapes (see Table 2.2 for definitions).

The UCBN monitoring program distinguishes cultural landscapes as distinct systems that exhibit unique and important ecosystem processes and interacts with surrounding ecosystems in profoundly important ways. It is within this context that the UCBN seeks to explicitly incorporate cultural landscapes into the vital signs monitoring program.

## VI. Summary of Key Resources and Natural Resource Threats and Issues

### A. Summary of Key Resources and Management Concerns

Resource managers were asked to identify the most important significant natural resources in their parks (Table 1.14). Cultural landscapes, fossil resources, kipukas (islands of vegetation isolated by lava flows at CRMO), riparian vegetation communities, and aquatic resources were identified as being the most significant resources in network parks. Vertebrate and plant species of concern were also identified as most significant, including the Townsend's big-eared bat and sage grouse at CRMO, water birds at LARO, and sensitive plant communities at JODA (see Appendix D-4 for list of UCBN species of concern).

Cultural landscapes are the most significant resource in at least 5 of the 9 network parks. At BIHO, NEPE, and WHMI, the entire acreage contained within the park is considered a cultural landscape. Other parks, such as CIRO and LARO, encompass cultural landscapes that are central to park mission.

Two parks (HAFO and JODA) were designated as National Park sites due to their fossil resources. The Smithsonian Horse Quarry at HAFO and the numerous fossil beds of JODA are nationally and internationally significant. These beds include some of the world's richest fossil deposits from the Eocene, Oligocene, and Pliocene Epochs.

Riparian vegetation communities were also identified by several parks as being a significant resource. Riparian communities support unique plant and animal species and provide important ecological services. Throughout the network these communities have been substantially altered by historic land use, invasive plants, development, and other impacts.

Table 1.14. Significant resources and management concerns in UCBN parks.

| Park | Significant Resources | Management Concerns |
|---|---|---|
| Big Hole National Battlefield (BIHO) | Cultural Landscape | Invasive plants, hydrology |
| City of Rocks National Reserve (CIRO) | California Trail, Indian Grove, riparian vegetation communities | Invasive plants, grazing, rock climbing impacts, dust dispersal and sedimentation, erosion |
| Craters of the Moon National Monument (CRMO) | Kipukas, class I airshed, lava tubes, geologic features, Sage grouse, Townsend's big-eared bats, | Invasive plants, destruction of geologic features by collectors, illegal off-road vehicle use, regional haze impacts on visibility, development impacts on night sky, and white pine blister rust impacts on limber pine |
| Hagerman Fossil Beds National Monument (HAFO) | Fossils and the associated stratigraphy | Altered hydrological regimes (high water tables, fluctuating reservoir levels, perched aquifers, irrigation) and wind/water erosion pose the biggest threats to slope stability and fossil resources, invasive plants |
| John Day Fossil Beds National Monument (JODA) | Fossil beds, Research Natural Areas, riparian vegetation, refugia for sensitive flora | Riparian area vegetation, changes in plant communities due to plant invasions, and reintroduction of fire |
| Lake Roosevelt National Recreation Area (LARO) | Aquatic resources, plant communities, raptors and water birds | Industrial pollution, residential development, and invasive plants |
| Minidoka Internment National Monument (MIIN) | Not included in survey | Not included in survey |
| Nez Perce National Historical Park (NEPE) | Cultural Landscape | Invasive plants |
| Whitman Mission National Historic Site (WHMI) | Cultural Landscape | Invasive plants, quality of irrigation water coming into the park |

B. Summary of Natural Resource Threats and Issues

UCBN parks share many similar natural resource threats and issues. The most fundamental is the profound alteration and disturbance of their landscapes. Lands undisturbed by human activities are rare in the region and an even smaller proportion of the remaining undisturbed lands are formally protected. Land use change, habitat alteration, and fragmentation are some of most important agents of change and source of resource stress in UCBN parks. The scarcity of protected lands within these provinces was illustrated in a survey that assessed the degree to which units of the national park system contained a representation of all natural regions in the country (National Park Service 1972). This assessment found that the various landscapes within the Columbia Plateau and Great Basin natural regions had the poorest representation within the national parks. Evidence of the lack of protection in these regions can also be found in the research of the Gap Analysis Program and by Wright et al. (2001) who has characterized the Snake River Plain and the Columbia Plateau - Palouse ecoregion as one of the least protected landscapes in North America. Conservation biologists have also characterized this region as an endangered ecosystem (Noss et al. 1995).

Threats or stresses originating from outside park boundaries can, and are, significantly modifying biodiversity and other valued components of park ecosystems (National Parks Conservation Association 1979, Garratt 1984, Machlis and Tichnell 1985, Sinclair 1998). In 1980, greater than 50% of threats reported across the National Park Service system were from external sources, with development on adjacent lands, air pollution, urban encroachment and roads and railroads most frequently cited (National Park Service 1980). More recently, land use change (Hansen and Rotella 2002), fragmentation (Ambrose and Bratton 1990), and human population density (Newmark et al. 1994), have been documented as threats to individual parks. In addition, climate change is likely to exert a strong influence on biodiversity within parks. It has been hypothesized that only protected areas with adequate expanses of surrounding habitat and linkages to other protected areas will be able to support current levels of biodiversity into the future (Hansen et al. 2001).

An essential step in the process of selecting vital signs is the gathering of park specific information on natural resources and the significant management issues and concerns facing those resources. In order to narrow the focus, ensure relevance to network parks, and increase efficiencies in the planning process, priorities must be established among focal resources and resource concerns. Network staff used several sources of information to summarize priority resources, stressors and resource concerns for the network. Park planning documents were reviewed and summarized, resource managers were surveyed about the stressors affecting park resources, and information was compiled by questionnaire concerning threats to water quality.

A survey of park resource managers confirmed that invasive / exotic plants had the highest negative impact on park resources. Other stressors with high negative impact rankings were agriculture practices on adjacent land, fire management practices, historic human impacts, NPS development, livestock grazing, recreational use, fire suppression, and landscape fragmentation.

The most common thread binding all parks in the network is the fact that they are islands located in areas of highly fragmented and often highly disturbed habitat. Most resource problems arise from the impacts caused by the mosaic of land uses around the parks and the legacy of historic land uses within existing park boundaries. Much less of a concern is the current land use and management activities within parks. The impact of current land use practices adjacent to park boundaries is compounded by the fact that all but one of the parks are small and lack external buffer zones that might mitigate impacts coming from lands external to the parks. The end result is that network parks are constantly beset by invasions of exotic plants and inputs from agricultural practices. They confront water and air quality problems due to agricultural and industrial activities on adjacent lands, and suffer from aesthetic impacts and intrusions, e.g., visual and noise pollution adjacent to the units. Along with these ecological problems, these factors disrupt the cultural setting many of the parks seek to portray. Viewsheds and soundscapes of cultural landscapes in the UCBN are at risk of degradation from outside land use changes.

## VII. Summary of Existing Monitoring and Partnership Opportunities

The UCBN staff is committed to complementing existing and fostering new regional collaborations that will benefit natural resource management within network parks. The 9 units occur over a 4-state area and are subject to a variety of adjacent land management strategies.

Like many park units across the US, parks in the UCBN tend to be "islands" in a sea of multi-use lands. For 8 of the 9 park units, the greater part of land within 5 miles of park boundaries is in private ownership. Only Craters of the Moon is surrounded by a majority of public lands, primarily BLM. The BLM manages >20% of the lands around 3 additional parks in southern Idaho (MIIN, HAFO, CIRO) and 1 park in Oregon (JODA). The USFS manages just over 40% of the land around BIHO in western Montana and also has important land holdings around CIRO, LARO, and NEPE. Small, but valuable portions of state lands occur within 5 miles of park units in all 4 states. Three of the parks in the network (CIRO, JODA, NEPE) are composed of multiple subunits. The most extreme case is NEPE, which consists of 38 subunits spread over all 4 states.

Monitoring efforts by agencies, other than NPS, may provide opportunities for partnership with the UCBN on natural resource projects aimed at wildlife, vegetation, air quality, water quality and weather conditions. Appendix E-3 summarizes the primary monitoring activities by adjacent land managers and/or other organizations that have been identified. In addition, numerous GIS and remote sensing data have been developed for UCBN parks and surrounding areas. These data, listed in Appendix E-2, will be invaluable for planning and conducting future monitoring.

Many of these surrounding land management agencies also designate areas for the long-term conservation of resources. At least 32 of these conservation areas occur within 10 miles of UCBN park units (Appendix B-2). Federal agencies manage 19, state agencies manage 10 and 3 are owned by The Nature Conservancy. Partnering with these entities as well as tribal and private landowners is essential for the long-term integrity of natural resources in UCBN parks (see Appendix D-3 for list of potential partners).

The lack of personnel to conduct monitoring in combination with the cultural resource focus of UCBN parks has limited the amount of natural resource monitoring currently occurring in network parks. The resource management staff at LARO collects observational data on wintering bald eagles for the USFWS. JODA and LARO have a fire effects monitoring plan that is coordinated and conducted by North Cascades National Park Complex. Groundwater dynamics monitoring is ongoing at HAFO, and WHMI is currently conducting a short-term soundscape monitoring project. Several parks participate in annual breeding bird surveys or Audubon Christmas bird counts but essentially none of the UCBN parks, except Craters of the Moon National Park and Preserve, conduct any formal natural resource monitoring.

We believe that it is important to acknowledge the existing monitoring program at CRMO as we build an integrated network monitoring program. Appendix E-1 contains a current list of ongoing monitoring projects at CRMO. The existing monitoring program at CRMO is focused on air quality, wildlife, and vegetation. Several of the listed projects have written protocol but none of the protocols have been peer-reviewed.

The lack of past monitoring activities in network parks serves to reinforce the importance of the UCBN monitoring program to this group of parks. Natural resource information from which resource managers can base sound decisions upon is virtually non-existent.

# Chapter 2. Conceptual Models

## I. Introduction

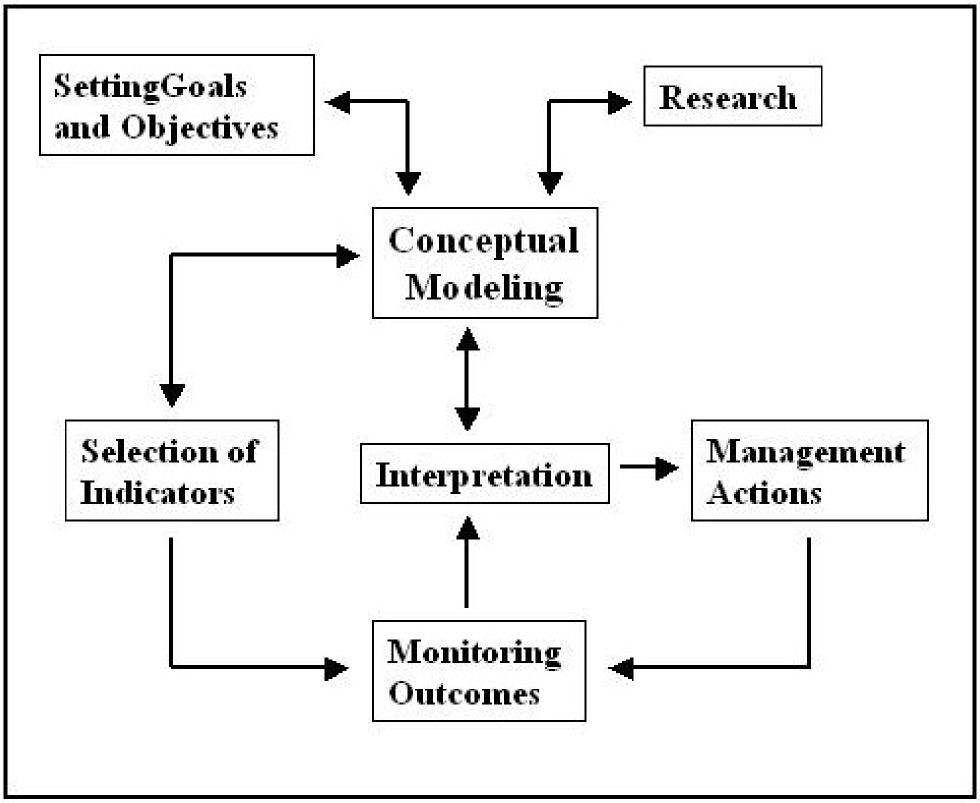
The inherent complexity of ecological systems presents a fundamental challenge to the development of a comprehensive and effective long-term ecological monitoring program. Long-term monitoring in the UCBN will help to predict, identify, and understand change in selected park resources that reflect ecological condition. The monitoring program will also deliver information about ecological change into the hands of park managers and partner agencies in a timely and useful manner. In order to achieve this, it is necessary to reduce the complexity of the world in which we design the program into a manageable set of key components and processes.

Conceptual modeling has been widely used in monitoring programs to distill complex systems into key elements (Manley et al. 2000, Noon 2003). Conceptual modeling is not a goal in itself but is a tool to guide the thinking, communication, and organization that goes into identifying the key ecosystem attributes and monitoring questions (Maddox et al. 1999). Conceptual models developed in concert with scoping sessions and other ground-level program development activities often directly point to measurable indicators (Maddox et al. 1999).

As an exercise, conceptual modeling can be effective in identifying gaps in knowledge as well as highlighting well understood ecosystem attributes (Roman and Barrett 1999). It is important to emphasize that conceptual models, as vehicles for communication and organization, reflect an iterative process and frequently remain in a dynamic "work in progress" condition rather than in a static "finished" state (Roman and Barrett 1999).  Conceptual models can play a central role in a monitoring program where models are refined and evolve as new information is gained through monitoring (Figure 2.1) (Maddox et al. 1999).

The UCBN began using conceptual models early in the process of building a vital signs monitoring program. In its first vital signs scoping workshop (April 2002) participants identified key ecosystem drivers, stressors, and ecosystem effects. A stressor-based model was developed during the course of the workshop that reflected the central management concerns of the network parks (see Appendix D-2). This original model was refined during preparation for the second vital signs scoping workshop held in March 2004 which resulted in a new set of models illustrating selected ecosystem and community dynamics and reflecting the network's progress in developing vital signs and monitoring questions. These models were used in the UCBN park-specific vital signs prioritization meetings held during winter 2005 and were revised again following these meetings. These most recent models are presented in Appendix C.

Figure 2.1. Central role of conceptual modeling in a dynamic monitoring program (adapted from Maddox et al. 1999).




## II. The UCBN Approach to Conceptual Modeling

The Critical Concept of Scale

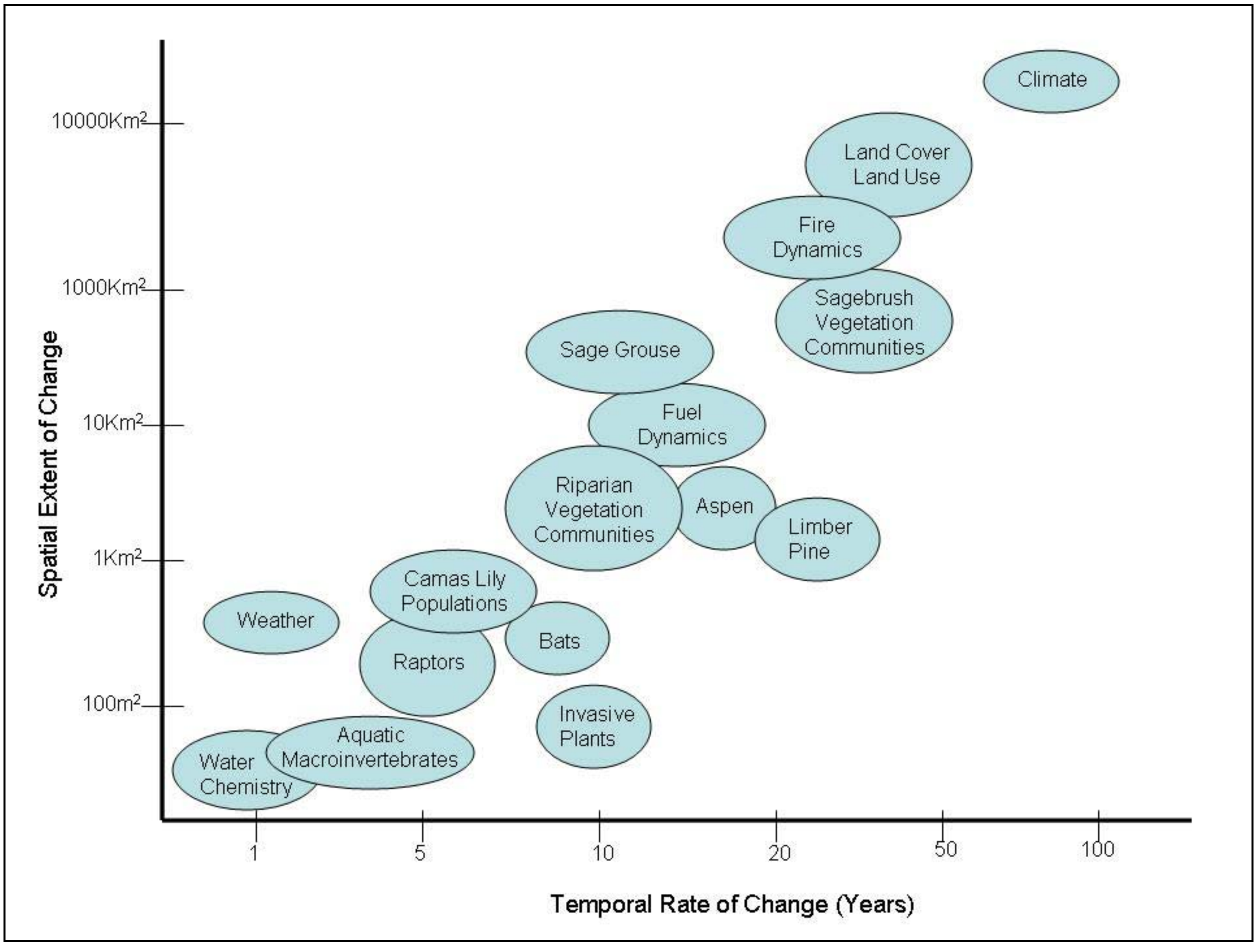
*"The problem of relating phenomena across scales is the central problem in biology and in all of science"* – Levin, 1992

A successful ecological monitoring program must be able to separate real change from inherent ecological variability. Temporal and spatial scale and the accompanying ecological organizational hierarchy act as lenses through which variability can become more or less focused. Patterns of variability may be apparent at one scale but not at another and meaningful detection of ecosystem change is dependent upon measurement at appropriate scales (Noss 1990, Morgan et al. 1994). Likewise, drivers, stressors, and effects may be operating at different scales simultaneously within a nested hierarchy (O'Neill et al. 1986, Wu and David 2002). The NPS I&M program, following suggestions by O'Neill et al. (1986), Noss (1990) and others (e.g. King 1993, Woodley et al. 1993), has identified integration of spatial, temporal, and ecological hierarchies as a key ingredient to network monitoring efforts (National Park Service 2003c). Integration involves the inclusion of hierarchical levels above and below the level of interest into conceptual models and monitoring designs.

Following an approach presented by Woodley et al. (1993) and adapted by several other NPS I&M networks (e.g. Liebfried et al. 2004, Mau-Crimmins et al. 2004), the UCBN has organized vital signs into three categories; threat-specific, focal resource, and ecosystem status (Figure 1.3). Selecting vital signs from each of these categories helps ensure a balanced and integrated program that can address the status and trends of ecological phenomena across a range of temporal and spatial scales, and for which effects are both known and unknown. The conceptual models developed by the UCBN reflect these categories, using both "stressor"-type and more mechanistic "control"-type models, and combining elements of both types in some models (Gross 2003). Stressor-effects relationships are widely represented in Appendix C because of the central role that stressor-effects and threat-specific vital signs have taken in the UCBN monitoring program to date. We believe this central focus on threat-specific vital signs will lead to a program that is highly relevant to park management and will yield important information of more global significance as well. UCBN park resource managers have consistently expressed concern over the impacts of a suite of approximately 6-10 anthropogenic stressors on park resources (Appendix D-6). Likewise, Dixon et al. (1997) and Olsen et al. (1997) have suggested that a focus on stressors and effects leads to more rich and interpretable results. This is consistent with the "issues orientation" promoted by Maddox et al. (1999) in which the goals of management and threshold levels triggering management action are explicitly identified and incorporated into the monitoring program. Noon et al. (1999) have also promoted a stressor-oriented approach to monitoring and have recognized the importance of establishing appropriate benchmarks with which to compare measured variability or change.

For many ecosystem attributes, however, effects of stressors are not well understood and threshold levels triggering management action are not easily articulated. A monitoring program based entirely on known stressor-effects relationships will fail in its ability to provide early-warning of new and emerging threats (Woodley et al. 1993, Woodward et al. 1999, Vos et al. 2000). Ecosystem status vital signs will help provide this early-warning capability and also, as independent explanatory covariates, provide greater interpretive power for observed changes and trends in threat-specific and focal resource vital signs (Bricker and Ruggiero 1998, Vos et al. 2000). Focal resource vital signs are those that by virtue of their special protection, public appeal, or other management significance, have paramount importance for monitoring regardless of current threats or their indication of ecosystem condition. In this sense, focal resource vital signs address either known (or hypothesized) and unknown or unanticipated stressor-effects relationships. Focal resource vital signs add much in the way of management relevance and applicability to the UCBN monitoring program, as well as to the ecological relevance of the program. Figure 2.2 illustrates the range of spatial and temporal scales represented by the prioritized set of vital signs, and indicates that at least some measure of integration is being achieved in the planning of the network monitoring program. Recognizing that the processes involved with each of these vital signs are operating across a range of spatial and temporal scales simultaneously, Figure 2.2 focuses on the primary scale of interest or observation for the UCBN. For example, the objective of the raptors vital sign is to monitor the trend of nest use and fledging success in areas affected by recreation and water pollution. The focus will be on changes at nest sites, which, after accounting for year-to-year variability in nest occupancy, should become evident over a period of about 5 years.

Figure 2.2. High priority vital signs organized according to the spatial extent and temporal rate of predicted or anticipated change in UCBN ecosystems.




As part of our effort to develop an integrated monitoring program, the UCBN has developed a set of nested conceptual models that focus on key community dynamics, stressor-effects relationships, and individual park focal resources that occur across a range of spatio-temporal scales and ecological hierarchies. Currently, the models and accompanying narratives reflect the Phase II focus of prioritizing a subset of previously identified monitoring objectives and vital signs. Models are more focused and detailed than those presented in the Phase I plan. The primary goal of these models is to illustrate the relationship of priority vital signs to ecosystem properties and processes, better facilitating communication within the UCBN science advisory committee as it refines monitoring questions and objectives and begins to develop sampling design and protocols.

## III. Focal Systems of the Upper Columbia Basin Network

The UCBN science advisory committee has identified five focal systems upon which the monitoring program will be based: cultural landscapes, sagebrush-steppe ecosystems, forest and woodland ecosystems, riparian ecosystems, and aquatic (lotic and lentic) ecosystems. These systems are defined primarily by land cover and encompass the suite of significant ecological resources of concern and from which measurable information-rich indicators have been drawn. Figure 2.3 illustrates the interrelationships among these five systems, the four global drivers that exert the strongest influence on the distribution of these systems across the region, and six broad stressor categories that represent the greatest threats to ecosystem condition and are of greatest management concern to UCBN parks. Table 2.1 lists the conceptual models built from these groups as components of the driver and stressor categories and accompanying narratives in Appendix C provide a review of relevant literature and an explanation of model properties. Ecosystem control models were designed to illustrate the primary drivers and stressors that control the distribution, composition, structure, and function of focal systems in the region. Submodels have been developed to provide more detailed descriptions of specific community dynamics and stressor-effects relationships. It is within these submodels that specific relationships between system processes, vital signs, and measures are illustrated.

Figure 2.3. The five major focal systems in the UCBN and the primary drivers and stressors that influence their distribution, structure, and function. Drivers are illustrated in gray boxes. Stressors are unboxed.

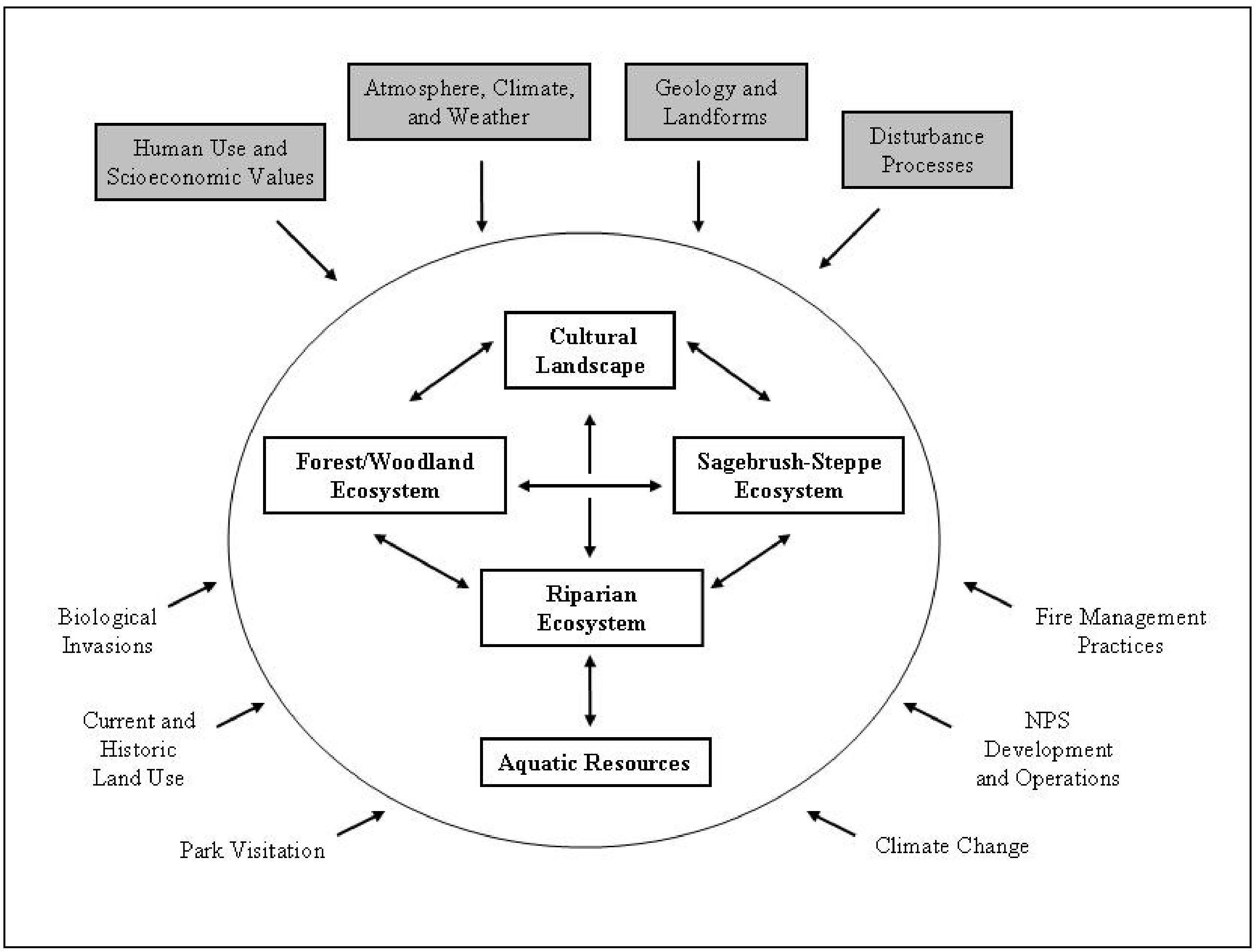


Table 2.1. Conceptual models developed for the UCBN vital-signs monitoring program (see Appendix C).

| Focal Ecosystem | Conceptual Model | Appendix C, Figure and Page Number |
|---|---|---|
| Cultural Landscape | Cultural Landscape Ecosystem Control Model | Fig. C-1, Pg. 70 |
| | Camas Lily Submodel | Fig. C-2, Pg. 71 |
| Sagebrush Steppe Ecosystems | Sagebrush-Steppe Ecosystem Control Model | Fig. C-4, Pg. 75 |
| | Sagebrush Altered Fire Regime Submodel | Fig. C-5, Pg. 76 |
| | Sage Grouse Population Dynamics Submodel | Fig. C-6, Pg. 77 |
| Forest and Woodland Ecosystems | Forest and Woodland Ecosystem Control Model | Fig. C-9, Pg. 85 |
| | Aspen Community Dynamics Submodel | Fig. C-10, Pg. 86 |
| | Limber Pine Community Dynamics Submodel | Fig. C-11, Pg. 87 |
| Riparian Ecosystems | Riparian Ecosystem Control Model | Fig. C-14, Pg. 93 |
| | Bat Community Dynamics Submodel | Fig. C-15, Pg. 94 |
| Aquatic Ecosystems | Aquatic Ecosystem Control Model | Fig. C-16, Pg. 100 |
| | Lotic Ecosystem Submodel | Fig. C-17, Pg. 101 |
| | Lentic Ecosystem Submodel | Fig. C-18, Pg. 102 |
| | Osprey Population Stressors Submodel | Fig. C-19, Pg. 103 |
| Land Cover | Land Cover / Land Use Control Model | Fig. C-20, Pg. 111 |

## A. Cultural Landscapes

In contrast to the Southwest Alaska Network, for example, where large, relatively pristine ecosystems still occur, the UCBN contains parks heavily influenced by historic and current human activities where only fragments of functioning "natural" ecosystems remain (USDA Forest Service 1996, Bennett et al. 2003). In addition, many UCBN parks were established to preserve some type of historic cultural landscape or feature. As a result, the human "scene" has been explicitly incorporated into the conceptual models not only as a key driver but also as a focal system that has its own unique ecosystem attributes and processes and requires a unique approach to vital signs monitoring. Without this explicit consideration, entire UCBN parks, such as Whitman Mission National Historic Site, would be greatly under-represented in the conceptual models developed for other focal systems. Although humans constitute a major influence even in pristine systems, the unique historic and legislative context of the UCBN requires this be addressed in the monitoring plan in a very fundamental way.

The NPS has been one of the leaders in the United States in defining and incorporating cultural landscapes into resource management, although the concept and utility of cultural landscapes in ecology has been much more widely exploited in Europe (La Pierre 1997, Taylor 2002). Birnbaum (1994), writing for the NPS, defines cultural landscapes as "a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values”. Interpreted broadly, this definition could be applied to most, perhaps all, landscapes in the network. However, existing NPS definitions of cultural landscape types help narrow this down somewhat and clarify what the cultural landscapes are for the UCBN monitoring program. The NPS recognizes four types of cultural landscapes: historic designed landscapes, historic vernacular landscapes, historic sites, and ethnographic landscapes (Birnbaum 1994). The definitions of each type are included in Table 2.2.

Table 2.2. NPS definitions for the four types of cultural landscapes

| | |
|---|---|
| **Historic Designed Landscape** | A landscape that was consciously designed or laid out by a landscape architect, master gardener, architect, or horticulturist according to design principles, or an amateur gardener working in a recognized style or tradition. The landscape may be associated with a significant person(s), trend, or event in landscape architecture; or illustrate an important development in the theory and practice of landscape architecture. Aesthetic values play a significant role in designed landscapes. Examples include parks, campuses, and estates. |
| **Historic Vernacular Landscape** | A landscape that evolved through use by the people whose activities or occupancy shaped that landscape. Through social or cultural attitudes of an individual, family or a community, the landscape reflects the physical, biological, and cultural character of those everyday lives. Function plays a significant role in vernacular landscapes. They can be a single property such as a farm or a collection of properties such as a district of historic farms along a river valley. Examples include rural villages, industrial complexes, and agricultural landscapes. |
| **Historic Site** | A landscape significant for its association with a historic event, activity, or person. Examples include battlefields and President's house properties. |
| **Ethnographic Landscape** | A landscape containing a variety of natural and cultural resources that associated people define as heritage resources. Examples are contemporary settlements, religious sacred sites, and massive geological structures. Small plant communities, animals, subsistence and ceremonial grounds are often components. |

All four cultural landscape types are represented in the network and seven of the nine UCBN parks contain at least one significant cultural landscape central to park enabling legislation. Table 2.3 lists the primary cultural landscapes in the UCBN. A number of these landscapes have been inventoried and evaluated (Beckham and Lentz 2000, National Park Service 2003b) and a region-wide effort is ongoing to complete more of these inventories (Gilbert 1991). A number of other landscapes in the UCBN, especially those that meet the definition of the ethnographic landscape type, remain outside formal designation but nonetheless are important and significant for the monitoring program.

Table 2.3. Landscapes and features representing the range of cultural landscapes within the UCBN. This list is not comprehensive and not all listed features are formally designated NPS cultural landscapes (* indicates formal designation).

| Cultural Landscape or Feature | UCBN Park | Cultural Landscape Type |
|---|---|---|
| Ft. Spokane (incl. parade grounds)* | LARO | Historic Site |
| Whitman Mission (entire NHS)* | WHMI | Historic Site |
| Cant Ranch (incl. farm fields) | JODA | Historic Vernacular Landscape |
| Big Hole Battlefield | BIHO | Historic Site |
| Heart of the Monster* | NEPE | Ethnographic Landscape |
| White Bird Battlefield | NEPE | Historic Site |
| Spalding Mission (entire site) | NEPE | Historic Vernacular Landscape |
| Spalding Arboretum | NEPE | Historic Designed Landscape |
| Weippe Prairie | NEPE | Ethnographic Landscape |
| Buffalo Eddy | NEPE | Ethnographic Landscape |
| Old Chief Joseph Gravesite | NEPE | Historic Site |
| Bear Paw Battlefield | NEPE | Historic Site |
| Minidoka Internment Site | MIIN | Historic Site |
| California Trail | CIRO | Ethnographic Landscape |

B. Sagebrush-Steppe

The term sagebrush-steppe generally refers to a number of plant assemblages dominated by one or more of the big sagebrush species (*Artemisia tridentata* ssp.) in association with perennial bunchgrasses and forbs (West and Young 2000, Bureau of Land Management 2002, Reid et al. 2002). The sagebrush-steppe ecosystem is often distinguished from sagebrush ecosystems of the Great Basin, in which the density of big sagebrush is much greater and perennial bunchgrass forms a relatively minor component of the system (Kuchler 1970, West and Young 2000). The climate of the sagebrush-steppe is generally cooler and more mesic than the Great Basin sagebrush zone (Bureau of Land Management 2002). Sagebrush-steppe is widespread throughout the Columbia Plateau, Snake River Plain, and northern Great Basin (West and Young 2000), and overlaps with a significant portion of the UCBN.

The sagebrush-steppe ecosystem is the most widely distributed ecosystem type within the network parks. Sagebrush-steppe comprises over 50% of land cover in CIRO, HAFO, and JODA. At CRMO, where bare lava rock comprises 81% of the total land cover, sagebrush-steppe represents over 90% of the existing vegetation cover (see Table 1.6). In the remaining parks of the UCBN, sagebrush-steppe is present and significant at LARO, is present as a transitional form in BIHO and occurs as minor relicts in MIIN, NEPE, and WHMI.

C. Forest and Woodlands

Forest and woodland ecosystems are the second most widespread ecosystem type in the UCBN, accounting for over 20% of the landscape in BIHO and JODA, and over 50% of the terrestrial land cover in LARO. Forest and woodland ecosystems are also significant at CIRO, CRMO, and NEPE. Small woody riparian areas are present at HAFO and WHMI and no woodland is present at MIIN. Forest and woodland types that occur in the UCBN include mixed fir and pine forest, ponderosa pine forest, limber pine woodland, pinyon-juniper woodland, aspen groves, and riparian cottonwood galleries. Much like cultural landscapes, forest and woodland ecosystems tend to be disproportionately important to the ecology of the UCBN and contribute significantly to the biological diversity. This is particularly well illustrated at CRMO, where the small stands of aspen, fir, and limber pine on the extreme north end of the monument contain a large number of vertebrates that are found nowhere else in the monument. Forests and woodlands of the network also play key roles in ecological processes that are important to current park management, including conifer encroachment into cultural landscapes, juniper expansion into sagebrush steppe, fuel accumulation, and fire. Recent discovery of a pinyon *Ips* beetle outbreak and related pinyon pine mortality at CIRO has focused attention on forest insect pathogens as well.

D. Riparian Ecosystems

Riparian zones comprise less than 1% of the total land cover of UCBN parks except at BIHO, where the floodplain of the meandering N. Fork Big Hole River supports extensive stands of willows and herbaceous wetland vegetation. As with the forest and woodlands and aquatic portions of the network, riparian zones are disproportionately important to the biological diversity and ecological processes of the UCBN, such as water retention and nutrient cycling (Gregory et al. 1991, Kauffman et al. 1997). Typical of semi-arid environments, riparian areas in the UCBN are typically narrow zones surrounding open water and transition abruptly to upland areas. Riparian types are defined primarily by vegetation and soil characteristics and are represented in the UCBN by woody wetlands such as cottonwood and alder galleries, willow thickets, and stands of herbaceous vegetation such as reed canary-grass, sedges, and rushes.

E. Aquatic Resources

Open water is relatively scarce in the UCBN, accounting for less than 1% of land cover, except for LARO, where Lake Roosevelt itself comprises 75% of the total park area. Both lotic (running water) and lentic (lake and pond) aquatic habitats are represented and, like the riparian and wetland habitats they support, are very important to the overall structure and function of network ecosystems. Most aquatic resources in the UCBN are lotic, and include large rivers, small creeks, and ephemeral springs and seeps. Lentic systems include the large reservoirs on the Columbia and Snake Rivers, Lake Roosevelt and Salmon Falls Reservoir, several oxbow lakes, small artificial ponds, and numerous ephemeral vernal pools associated with geologic features at CIRO and CRMO.

## IV. Ecosystem Drivers

Ecosystem drivers are major external driving forces such as climate, fire cycles, biological invasions, hydrologic cycles, and natural disturbance events (e.g., earthquakes, droughts, floods) that have large scale influences on natural systems. This section briefly introduces the major driving forces of UCBN ecosystems. These drivers, or specific elements of them, figure prominently in the conceptual models presented in Appendix C.

### A. Atmosphere, Climate, and Weather

The atmosphere, made up largely of nitrogen, oxygen, and varying amounts of carbon dioxide ($CO_2$), ozone, and water vapor, provides the essential life-sustaining service of planetary thermoregulation, protects biotic organisms from excessive levels of solar radiation, and interacts with the lithosphere to drive the hydrologic and nutrient cycles. Planetary orbit, rotation, and axis tilt interact with the atmosphere to drive seasonal solar input cycles. Heat from solar radiation combines with planetary rotation to drive major atmospheric circulation, manifest as wind, in turn driving the major climatic zones of the planet. Local climate and weather patterns are created by the interaction of the tremendously variable forces of topography, ocean temperature circulation, and circulation of the atmosphere. The latitudinal position of the UCBN receives insolation at an oblique angle, making it a relatively cool region. Interaction of latitude, prevailing westerly winds, and the Cascade Mountains to the west has created a cool, semi-arid climate subject to seasonal temperature extremes and highly variable seasonal precipitation patterns. Variability in weather and climatic patterns in the region are driven by the interaction of changes in ocean circulation (Pacific Decadal Oscillation), changes in atmospheric composition, primarily water vapor and $CO_2$, and elevation. This variability occurs across a broad range of spatiotemporal scales and, in concert with geology and landforms, exerts the most fundamental driving forces on the distribution, form, and function of UCBN ecosystems.

### B. Geology and Landforms

Tectonic, volcanic, and surficial geomorphic processes drive contemporary ecosystems in the UCBN. These processes give rise to landforms, or topography, which, as stated previously, interact with the atmosphere and climate in fundamental ways. The effect of elevation on precipitation and aspect on evaporation, referred to as the topographic-moisture gradient, is the primary example of this, and largely explains the distribution of sagebrush-steppe, pinyon/juniper woodland, and coniferous forest across the region (Whittaker 1967, Peet 2000). Although elevational gradients are relatively low within the park boundaries, largely due to their small size, gradients are quite steep in much of the surrounding landscapes and in the region as a whole. Geologic and geomorphic processes also provide the parent material for soil development. Again, with interaction from atmospheric and climatic forces, weathering and soil development is tightly bound to network ecosystems and soil type is a fundamental driver of vegetation distribution and composition.

### C. Human Use and Socioeconomic Values

Humans have been a profound source of ecosystem change in the Columbia Basin (USDA Forest Service 1996, Marquet and Bradshaw 2003) and the long-term ecological trajectories of UCBN ecosystems and landscapes are heavily influenced by historic land use and disturbance regimes as well as societal values (Rapport et al. 1998, Foster 2002). The fundamental role of humans in shaping and controlling ecosystems is represented in Figure 2.4 as a global driver and as a cultural landscape focal system. Anthropogenic influences are the primary ecosystem stressors and understanding and modeling both historic and contemporary human impacts is an important ingredient in the monitoring program. Human use and manipulation of regional ecosystems have ranged from pre-historic use of prescribed fire, to rerouting of streams for irrigation and flood control, to the creation of entirely artificial ecosystems, such as some of the cultural landscapes.

### D. Disturbance Processes

A disturbance can be defined as a relatively discreet event that disrupts structure of a community, population, or ecosystem and changes resource availability or the physical environment (White and Pickett 1985). Disturbances vary in space and time and are described in terms of frequency, intensity, and size.  These characteristics determine the ecological impact of a disturbance event or regime. Disturbances can become stressors when frequency, intensity, or size exceeds the limits of natural variability. In the UCBN, fire is an important disturbance driver and most vegetation communities are adapted, or in some way resilient, to fire. Depending on the plant community, historic fire regimes in the region range from frequent, low-intensity fires to infrequent, high-intensity fires (Agee 1993). Fire suppression and the establishment of non-native invasive vegetation has significantly altered historic fire regimes and contributed to profound changes in ecosystem structure and function (D'Antonio and Vitousek 1992). Other important disturbance agents in the UCBN include floods, landslides, and forest insect outbreaks.

## V. Ecosystem Stressors and Ecosystem Effects

Ecosystem stressors are physical, chemical, or biological perturbations to a system that are either (a) foreign to that system or (b) natural to the system but applied at an excessive [or deficient] level. Stressors cause significant changes in the ecological components, patterns, and processes in natural systems. Examples include water withdrawal, pesticide use, timber harvesting, traffic emissions, stream acidification, trampling, poaching, land-use change, and air pollution. This section introduces the major stressors influencing UCBN ecosystems, all of which are anthropogenic or, in the case of accelerated climate change, hypothesized as anthropogenic.

### A. Biological Invasions

Non-indigenous invasive species are a major threat to native species diversity and ecosystem function, causing economic impacts within the U.S. estimated at more than $100 billion annually (Pimentel et al. 1999). In addition to competing with and displacing native species, establishment of introduced species leads to a positive feedback loop and alters conditions to promote the establishment and spread of other non-native species. This is particularly evident in the upper

Columbia Basin and other arid environments in which non-native annual grasses alter fire regimes, in turn creating conditions favorable to further plant invasion (Mack and D'Antonio 1998, Bunting et al. 2002). Invasive species have been called the "single most formidable threat of natural disaster of the 21st century" (Schnase et al. 2002). Non-native plant invasion is the most difficult and pressing management concern in the UCBN with 36 different species affecting at least one network park (Appendix D-5). Invasive animals are also of significant concern, most notably the bullfrog and various non-native gamefish, which have contributed to the extirpation of several species of native amphibians in several UCBN parks.

B. Current and Historic Land Use

The Columbia Basin has been occupied and manipulated by humans for millenia (USDA Forest Service 1996). However, as a source of ecosystem stress, land use practices introduced during the settlement era in the latter half of the $19^{th}$ century are most relevant (Mack 1981, Yensen 1981, Todd and Elmore 1997, West and Young 2000, Reid et al. 2002). There are very few, if any, areas within UCBN parks that have not been subjected to some form of historic anthropogenic stress. Even in remote portions of CRMO, evidence of historic mining and historic invasive plant introductions are evident. A recent study of vegetation in remote kipukas (islands of vegetation surrounded by lava) in CRMO have found that some are relatively free of invasive plants (Huntley and Pedersen, Idaho State University, unpublished data), and these areas represent the most pristine ecosystems in the network. Intensive livestock grazing, non-native plant introductions, agricultural conversion, irrigation and flood control related manipulations, and fire suppression represent the most ecologically significant and pervasive historic human stressors in the region.

Over the past century, land use dynamics in the rural western United States have shifted from livestock grazing, agriculture and mining to suburban and ex-urban development (Johnson 1998, Rudzitis 1999, Hansen et al. 2002). Although this process is occurring at variable rates within the region, ex-urban development is evolving as a major force in land conversion and is certain to have considerable impacts on biodiversity in parks and neighboring ecosystems (Hansen et al. 2002). Livestock grazing, hay and vegetable crop production, and other agricultural land use activities also continue to be widespread in lands surrounding UCBN parks. Habitat fragmentation, resulting from both ex-urban and agricultural land use change surrounding UCBN parks, diminishes habitat quality and quantity and alters the pattern and distribution of habitat, further altering the movement of organisms and across the landscape (Ambrose and Bratton 1990, Harrison and Fahrig 1995, Trombulak and Frissell 2000). Adjacent land use practices influence the spread of invasive species into UCBN parks, as well as water and airborne contaminants such as agricultural chemicals and excessive nutrients. Upstream water withdrawals affect aquatic and riparian ecosystems in several UCBN parks.

C. Fire Management Practices

Both fire suppression and use of prescribed fire are employed by land managers within UCBN parks and on surrounding lands. Thinning of trees for fuel reduction, a widespread practice throughout forest lands in the region and practiced at LARO, is done for both suppression and to facilitate use of prescribed fire. While fire management objectives often aim to increase ecological condition, the effects of these practices are controversial and a cause of (unintended) reduced ecological integrity in many cases (Tiedemann et al. 2000, Keane et al. 2002, Bunting et al. 2002). Of particular concern is the unresolved question of historic fire regimes and historic forest and rangeland structure and composition (Simberloff 1999, Tiedemann et al. 2000, Baker and Ehle 2001, and Soulé et al. 2004). In many sagebrush-steppe ecosystems, the risk of increasing non-native plant invasion through prescribed burning is high (D'Antonio and Vitousek 1992, D'Antonio 2000, Bunting et al. 2002). The effects of fire management practices on primary productivity, nutrient cycling, and biological communities are not well understood but represent a potentially very significant ecosystem stressor.

### D. NPS Park Development and Operations

Growth in regional populations and associated rise in visitation increases demand on existing park resources and leads to new expansion in infrastructure and operations. For instance, park roads may need to be resurfaced or extended, parking lots may need to be expanded, visitor and interpretive centers, campgrounds, and other facilities may need to be built or upgraded. All of these developments have the potential to become significant ecosystem stressors. Ongoing park operations related to park mission, including permitted grazing and maintenance of historic agricultural landscapes, are additional sources of ecosystem stress. In addition to fire management practices, weed control efforts and other resource management practices can be significant stressors as well.

### E. Park Visitation and Recreation

Estimates of annual park visitation in the UCBN from the period 1992 to 2002 have remained relatively constant with a network average of approximately 250,000 visitors, but range from 12,000 at HAFO to over 1 million in LARO (National Park Service Public Use Statistics Office http://www2.nature.nps.gov/stats/). However, several parks in the network are concerned about increasing visitor use and all parks are responding to heavy, albeit localized, visitor impacts at current levels of use. Visitor use creates demands for continued park development, or upgrade of existing development, particularly trails, which fragment wildlife habitat, bring people into sensitive areas, and contribute to off-trail use in these sensitive areas (National Park Service 1997). Recreational uses in these parks have the potential to impact park resources through trampling, disturbance to aquatic resources, behavioral disturbances to wildlife, and damage to cultural resources. In addition, the introduction and spread of exotic invasive plant species by visitors poses a significant challenge to ecosystem management. The actual level of impacts depends on variables such as patterns of visitor concentration and the intensity of specific activities (i.e., rock climbing at CIRO and boating and fishing at LARO).

### F. Climate Change

The greenhouse effect, which warms the Earth's atmosphere, results from the interaction of solar radiation with accumulated greenhouse gases (e.g., carbon dioxide, methane, chlorofluorocarbons, and water vapor) in the atmosphere. This warming effect has been enhanced over the past century by increased contributions of these gases, particularly carbon dioxide, from anthropogenic sources (NAST 2001). Climate models suggest that the Great Basin and Columbia Basin may get warmer and wetter over the next 100 years (Wagner et al. 2003). Predicting effects of global warming are complicated by interactions with global precipitation patterns (most notably for the upper Columbia Basin is the El Nino-Southern Oscillation). Altered precipitation patterns may lead to reduced snowpack and increased summer rain, although a net drying effect, rather than a more mesic summer climate, seems more likely (Melack et al 1997, Wagner et al. 2003). Increases in mean annual temperature and increased temperature extremes may occur, as well as elevated levels of $CO_2$. Possible ecosystem effects include increased fire frequency and intensity, increased rates of plant invasions, and increased rates and extents of plant pest outbreaks (D'Antonio 2000, Smith et al. 2000, Logan and Powell 2001, Whitlock et al. 2003, McKenzie et al. 2004).

# Chapter 3. Vital Signs

## I. Introduction

Monitoring seeks to determine the status of and detect trends in ecological indicators of interest (Busch and Trexler 2003). An effective monitoring strategy directly addresses resource monitoring goals (Elzinga et al. 1998), which are often vague and reference maintaining or attaining some state of favorable "ecosystem health" or "ecosystem integrity" as their ultimate goal (Busch and Trexler 2003). As the traditional view of the "balance of nature" has been replaced by recognition that ecosystems are dynamic, variable systems, the use of ecosystem "health" and "integrity" has been criticized (Suter 1993, Wicklum and Davies 1995, Woodward et al. 1999). Further, these terms imply that science has some objective, precise, quantitative definition of a "healthy" ecosystem. Noon (2003) acknowledged the limitations of "ecological integrity," but contended that, though vague, the term has merit for communicating monitoring goals to managers. We prefer the more value-neutral term "ecological condition," (Busch and Trexler 2003) because:

A. Desired conditions are set by the managers and policy makers entrusted with the care of the land management unit. An overarching set of ideal conditions is not assumed. For the NPS, these desired future conditions are described in the mission of the park, environmental laws, and enabling legislation. Linking these relatively vague mandates for resource management and protection to specific, measurable conditions is the shared task of scientists, managers, policy makers, and the public in whose name these lands are managed.

B. "Integrity" implies a binary assessment of ecological conditions; either the ecosystem has integrity (is functioning) or does not (is not functioning). While thresholds and trigger points play important roles in ecosystem dynamics and monitoring, "ecological condition" better reflects the non-equilibrium character of ecosystems, in which routine natural disturbances such as fire, herbivory, and climatic extremes play important roles.

Noon (1999, 2003) provides a useful step-down approach for designing an ecological monitoring program that has been adopted by the UCBN. This method contains seven sequential key issues to address in the design of a successful monitoring program (Figure 3.1):

1. *Specify goals and objectives.* The most fundamental goal of an ecological monitoring program is to determine the status and detect trends in particular attributes (indicators) of ecosystems. However, the ultimate goal of ecological monitoring is to provide direction for effective natural resource management, particularly adaptive resource management (Holling 1978, Walters 1986). Goals of the NPS I&M Program are presented in Chapter 1.

2. C*haracterize stressors and disturbances.* To be relevant to resource management, indicators must be linked to known and predicted anthropogenic stressors of target ecosystems. A detailed evaluation of stressors and resource management goals and concerns is presented in Chapters 1 and 2.

3. *Develop conceptual models- outlines the pathways from stressors to the ecological effects on one or more resources.* Conceptual models summarize our knowledge of how particular ecological systems operate and are arranged. An ecological overview of UCBN natural resources appears in Chapter 1. Chapter 2 provides conceptual models for each selected vital sign.

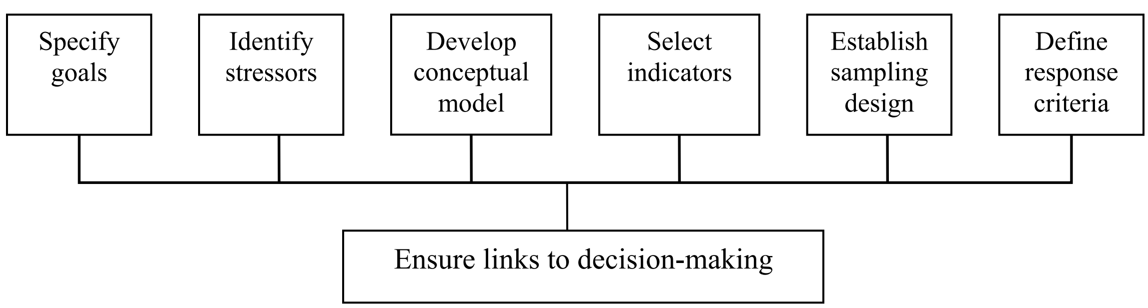
4. *Select indicators – detect stressors acting on resources.* Candidate indicators (vital signs) and the processes used to determine them are presented in this chapter.

5. *Determine detection limits for indicators – to guide sampling design.* This process will take place through quantitative assessment of vital signs and measures as a part of protocol development.

6. *Establish"trigger points" for management intervention.* This process will take place through quantitative assessment of vital signs and measures and evaluation of known (or hypothesized) thresholds and triggers as a part of protocol development.

7. *Establish clear connections to the management decision process.* Management responses to monitoring results are the responsibility of park management within the guidelines of the NPS mission, policy, enabling legislation, and applicable regulatory mandates. The UCBN staff is committed to ensuring the long-term future of the monitoring program by establishing clear connections to management decisions made by park resource managers and superintendents.

Figure 3.1. A sequential list of key issues to address in the design of a prospective monitoring program (Noon 2003).




## II. Overview of the Vital Sign Selection Process

The complex task of developing a network monitoring program requires a front-end investment in planning and design to ensure that monitoring will meet the most critical information needs of each park and produce scientifically credible data that are accessible to managers and researchers in a timely manner. The investment in planning and design also ensures that monitoring will build upon existing information and understanding of park ecosystems and make maximum use of partnerships with other agencies and academia. Collectively, the information used to build the monitoring program also functions as ideal criteria by which ecological indicators can be compared and selected for inclusion in the network's vital signs monitoring program. Although

NPS I&M networks are not required to follow set methodologies for selecting indicators, it is understood that selection of vital signs is an iterative process. Selected vital signs may be added to the program as fiscal resources and management issues change. Adjustments to the monitoring program also may occur as subsequent monitoring program reviews, conducted approximately every five years, provide feedback on the efficacy of the selected indicators.

The UCBN vital signs prioritization process involved multiple-steps including the use of conceptual-models and formal criteria-based team decisions (Figure 3.2). The primary purpose was to provide objective identification and ranking of ecosystem vital signs that would be the focus of long-term monitoring. Explicitly, our processes first identified vital signs as being suitable for monitoring, then ranked or prioritized them.

Our process was based on team discussion and analysis of conceptual models that summarize diverse abiotic and biotic components and functional aspects of ecosystems. One key feature was the use of simplified "sub-models" that focus on small sections of ecosystems. The sub-model approach served to focus team attention on discrete ecosystem variables. The conceptual models are discussed in detail in Chapter 2 and Appendix C. Another key feature of the ranking process was the use of selection criteria, together with a defined numerical scoring system, to quantify each vital sign ranking (selection criteria are described in Table 3.1). This strategy permitted a high degree of objectivity in the selection process. Greater objectivity lends greater credence to the overall process, increases our confidence in the outcome, and enhances the overall validity of our program.

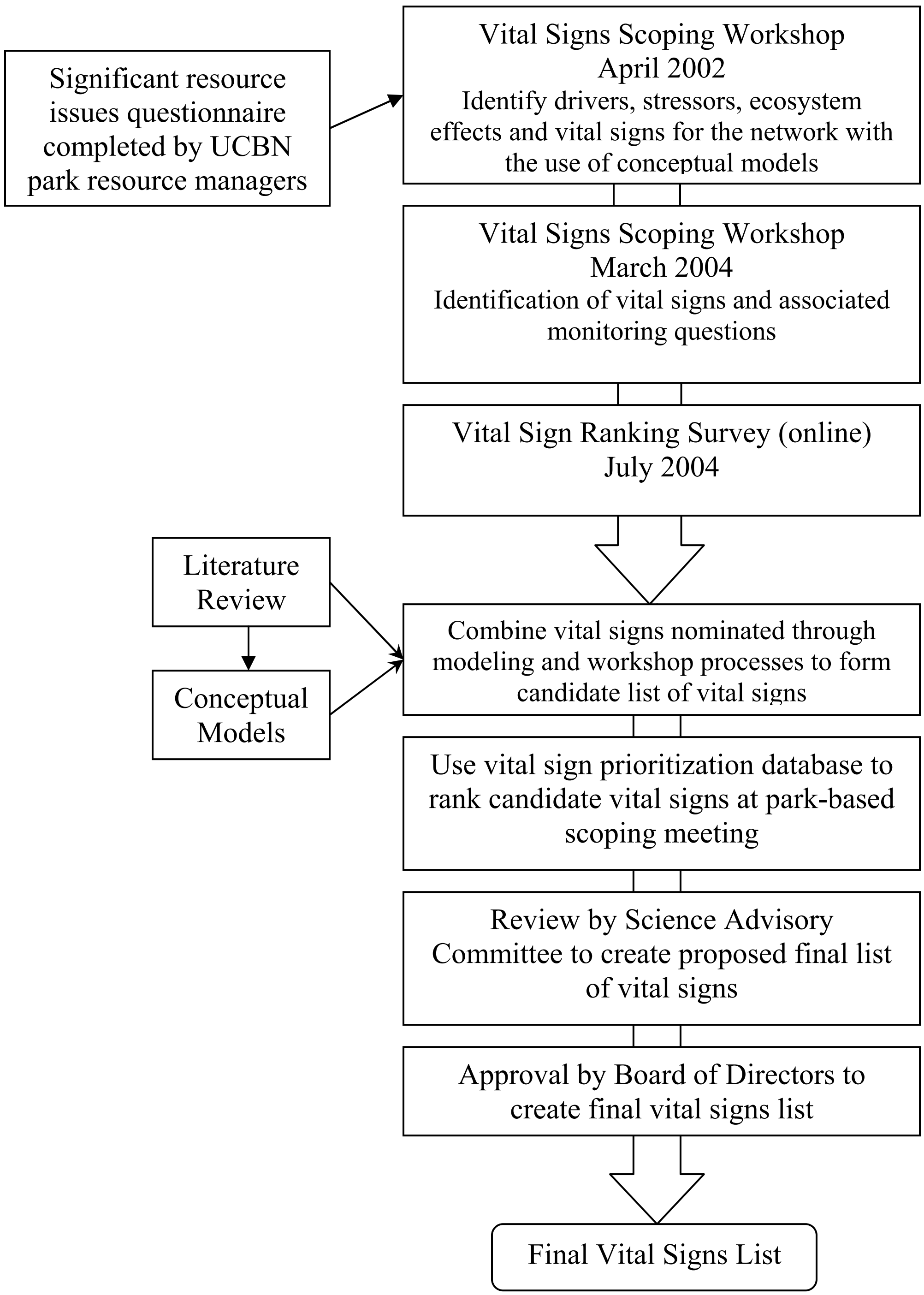
An essential component in process implementation was the use of a team discussion format. This format emphasized open discussion of models, vital signs, issues and concerns, and application of criteria and scoring in a consensus-based manner that sought active contribution from all team participants. Team discussion and consensus-building also enhanced objectivity while supporting real consideration of diverse perspectives, expertise, and interests of park managers and the contributing "outside experts". The following sections (A-F) explain the UCBN vital sign selection and prioritization process in more detail.

A. Regional Workshops
(Workshop reports can be downloaded from the following website:
http://www.nature.nps.gov/im/units/ucbn/ReportTable2.htm#Monitoring)

Regional workshops were held in 2002 and 2004 at the University of Idaho in Moscow, Idaho. The workshops provided a forum for scientists from various disciplines to brainstorm on potential vital signs and monitoring questions that would assist the Network in monitoring the ecological condition of UCBN parks.

The first regional workshop was held in April 2002 and was organized to identify and validate vital signs common to each park site, substantiate the premises of the conceptual model, further develop the monitoring focus, and identify preliminary measures and methods. In preparation for the first workshop, the network staff completed a computerized resource database documenting all natural resource studies pertaining to each park site, species lists for each park in the network

Figure 3.2. Model depicting the Chapter 3-related elements of the UCBN vital signs prioritization and selection processes.



and information on existing natural resource data. To avoid a "death by models" situation, a simple, straightforward conceptual model was developed before the workshop, providing a starting point and framework for addressing and evaluating vital signs and monitoring strategies at the network level. Prior to the workshop, resource managers were sent a questionnaire examining the following points as preparation for workshop discussions:

- What are your park's most significant resources for which information about status and trends is needed?
- What park resources have regional or even national significance due to their unique nature or because they serve as indicators of regional trends?
- Are there particular resources that the park has special mandates or commitments to protect either by park legislation, in a general management plan, or in other planning documents? (e.g., Federally listed species at all parks)
- What, in your opinion, are the greatest current or prospective internal threats to significant park resources? (e.g., climbing at CIRO, trail impacts at JODA)
- What are the greatest external threats? (e.g., irrigation at HAFO)
- Are there significant current or future ecosystem restoration projects in the park for which long-term monitoring is needed? (e.g., vegetation restoration projects at WHMI)
- What long-term natural resources monitoring projects have been undertaken in the past or are ongoing now?

Resource Managers responded to the questionnaire in writing and a summary of their responses is contained in Appendix D-1. Park summaries were prepared for this workshop that contained information on the size of the park, designation date, park history and purpose, location, elevation, climate, fauna, flora, unique features, species of special concern and resource management concerns (Appendix D).

The conceptual model developed for the workshop was altered to best reflect workshop findings (Appendix D-2). The final column of the model listed the vital signs considered by workshop participants to be the most important to monitor in the network. Vital signs included riparian/wetlands community, grassland/shrub-steppe community, herpetofauna, avifauna, small mammal community, invertebrate community and soil properties.

Between the 2002 workshop and the 2004 workshop the Network focus was on completion of vertebrate and vascular plant inventories in all the UCBN parks. Network and park staff participation in the completion of natural resource inventories aided them in becoming familiar with park resources. Baseline inventories delivered important and fundamental information to park managers about the presence and distribution of plants, animals, and nonliving resources such as water, landforms, and climate in the parks. The information gained from completion of the natural resource inventories was used to assist participants in the second regional workshop in making more informed decisions about the selection of vital signs for the parks.

A second Network-wide workshop was held in March 2004. The purpose of this workshop was to continue to solicit input from park managers and regional scientists on potential vital signs and associated monitoring questions. Heavy emphasis was placed on the development of monitoring questions, since it was becoming clear to the UCBN staff that vital signs were of limited value without an associated set of status-and-trend type questions. The outcomes from this workshop included: 1) the creation of a network of stakeholders, 2) a review of technical information developed by the science advisory committee, and 3) the development of a list of vital signs and associated monitoring questions that help track a subset of the total suite of natural resources that park managers are directed to preserve.

A network of stakeholders was established by contacting resource professionals from agencies that have land adjacent to park lands and by speaking to references provided by park resource managers. Potential partners were identified (Appendix D-3) and scientists from many different natural resource disciplines and agencies participated in the 2004 network workshop.

A primary emphasis of UCBN efforts in 2004 was to define the most significant resources, resource concerns and stressors within UCBN parks. Information from questionnaires sent to network resource managers before the workshop was presented to workshop participants. This information included a list of species of concern (Appendix D-4), a noxious weed list (Appendix D-5), and a list of prioritized stressors affecting park natural resources (Appendix D-6).

An important component of the vital signs selection process has been the conceptual modeling efforts conducted during the previous vital signs scoping workshop and more recent efforts detailed in Chapter 2 of this report. Following the second vital signs workshop, the UCBN staff identified 5 broad ecosystem categories into which most vital signs and questions developed in the workshop could be placed: cultural landscapes, sagebrush-steppe ecosystems, forest and woodland ecosystems, riparian and wetland ecosystems, and aquatic resources. These five focal systems are primarily defined by land cover and vegetation type and encompass the suite of significant ecological resources of concern from which measurable information-rich indicators were developed. An extensive literature review and a suite of updated conceptual models reflecting the network's progress in vital signs selection is presented in Chapter 2 and Appendix C.

B. Vital Sign Ranking Survey (online)

Following the 2004 workshop, a vital signs ranking survey was developed by Dr. Edwin Krumpe (University of Idaho professor and workshop facilitator) and placed online for a period of 45 days. Workshop participants and other stakeholders were solicited by email to complete individual ranking exercises for the list of vital signs and associated monitoring questions developed during the regional scoping workshop held in March 2004.

In this survey, a comprehensive list of vital signs and candidate monitoring questions was provided from the 2004 Workshop and each participant was asked to rank each question for its importance and value as an indicator of ecosystem condition and significance to management. This questionnaire was organized around the five resource categories used as workgroups in the workshop – vegetation, wildlife, soils/geology, water/riparian, and air/climate/landuse. Survey participants were queried to submit additional monitoring questions that the network should consider.

Ranking was completed on the value of each vital sign and associated monitoring question as an indicator of ecosystem condition and management significance and new questions were offered by some participants. Thirty-four stakeholders participated in the ranking exercise. The UCBN staff conducted a review of the survey results and further refined the preliminary list of vital signs (Appendix D-7) to fifty-seven high priority vital signs with associated monitoring questions. The UCBN used this list of fifty-seven candidate vital signs to proceed to the next step in the prioritization process which was the development of a Vital Signs Prioritization Microsoft ACCESS database.

C. Development of a Microsoft ACCESS database for Vital Sign Prioritization

The UCBN chose to use an ACCESS database to prioritize fifty-seven candidate vital signs developed from two regional workshops. Adopting this database approach offered several advantages to the Network in the Vital Sign Prioritization process. The use of the database in park-focused workshops gave participants the opportunity to:

- Review vital sign objectives, existing protocols, and partnership opportunities.

- Review threats and management concerns and complete a prioritization of vital signs by park.

- Interact with each other to ensure that the list of vital signs for individual park units reflected the consensus view of the resource management staff at the park level.

- View the network list of vital signs after the park-level vital signs were prioritized.

Screen captures from the Microsoft ACCESS database are included in Appendix D-8. The ACCESS database used by UCBN to prioritize 57 candidate vital signs was modified from a database developed by Dr. Steven Fancy (WASO) and Kris Heister (MOJN). The UCBN candidate vital signs and associated monitoring questions were input into the Microsoft ACCESS database by Leona Svancara (UCBN data manager) and categories were labeled to reflect the ranking process and criteria used by the UCBN.

The ranking process considered a vital sign's ecological significance, park management significance and legal mandate in the final ranking. Each of these categories was weighted with ecological significance (40%), park management (40%), and legal mandate (20%) of the total. The weighting could be modified if a park desired to place more emphasis on one criteria over another. Each of the candidate 57 vital signs was scored by the criteria shown in Table 3.1.

D. Park-level Scoping Workshops

The final step in the vital sign ranking process for UCBN parks focused on a candidate list of 57 vital signs and associated monitoring questions developed for each park through conceptual modeling and regional workshops. Conceptual models and submodels were used to illustrate the vital signs identified for the UCBN five focal systems (Chapter 2). The database was used for each park-level meeting by projecting the database contents on a screen so that workshop

Table 3.1. Upper Columbia Basin Network criteria for ranking vital signs.

| |
|---|
| **Management Significance 40%** |
| • For this potential vital sign, how many of the following statements do you STRONGLY AGREE with? |
| • There is an obvious, direct application of the data to a key management decision , or for evaluating the effectiveness of the program. |
| • The vital sign will produce results that are clearly understood and accepted by park managers , other policy makers, research scientists, and the general public. |
| • Monitoring results are likely to produce early warning of resource impairment, and will save park resources and money if a problem is discovered early. |
| • In cases where data will be used primarily to influence external decisions, the decisions will likely affect key resources in the park, and there is a great potential for the park to influence the external decisions. |
| • Data are of high interest to the public. |
| • For species-level monitoring, involves species that are harvested, endemic, invasive, or at-risk biota. |
| • There is an obvious, direct application of the data to performance (GRPA) goals. |
| • Contributes to increased understanding that ultimately leads to better management. |
| VERY HIGH: Strongly aggress with all 7 of the statements above.<br>HIGH: Strongly agree with 6 of the statements above.<br>MODERATE: Strongly agree with 5 of the statements above.<br>LOW: Strongly agree with 3 or 4 of the statements above.<br>NONE: Strongly agree with 2 or fewer of the statements above. |
| **Ecological Significance 40%** |
| • There is a strong, defensible linkage between the vital sign and the ecological function or critical resource it is intended to represent. |
| • The resource being represented by the vital sign has high ecological importance based on a conceptual model of the system or is well-supported by the ecological literature. |
| • The vital sign characterizes the state of unmeasured structural and compositional resources and system processes. |
| • The vital sign provides early warning of undesirable changes to important resources. It can signify an impending change in the ecological system. |
| • The vital sign reflects the functional status of one or more key ecosystem processes or the status of ecosystem properties that are clearly related to ecosystem processes. [Note: replace the word ecosystem with landscape or population, as appropriate.] |
| • The vital sign reflects the capacity of key ecosystem processes to resist or recover from change induced by exposure to natural disturbances and/or anthropogenic stressors. [Note: replace the word ecosystem with landscape or population, as appropriate.] |
| VERY HIGH: Strongly agrees with all 6 of the statements above.<br>HIGH: Strongly agree with 5 of the statements above.<br>MODERATE: Strongly agree with 3 or 4 of the statements above.<br>LOW: Strongly agree with at least 1 of the statements above.<br>NONE: This is an important attribute to monitor, but I do not agree with any of the statements above. |
| **Legal Mandate 20%** |
| • VERY HIGH: The park is required to monitor this resource by some specific, binding, legal mandate (e.g., Endangered Species Act for an endangered species, Clean Air Act for Class 1 airsheds), or park enabling legislation that mentions a specific resource to be monitored. |
| • HIGH: The resource/vital sign is specifically covered by an Executive Order (e.g., invasive plants, wetlands) or a specific Memorandum of Understanding signed by the NPS (e.g., bird monitoring), as well as the Organic Act, other general legislative or Congressional mandates, and NPS Management Policies. |
| • MODERATE: There is a GPRA goal specifically mentioned for the resource/vital sign being monitored, or the need to monitor the resource is generally indicated by some type of federal or state law as well as the Organic Act and other general legislative mandates and NPS Management Policies, but there is no specific legal mandate for this particular resource. |
| • LOW: The resource/vital sign is listed as a sensitive resource or resource of special concern by credible state, regional, or local conservation agencies or organizations, but it is not specially identified in any legally-binding federal or state legislation. The resource/vital sign is also covered by the Organic Act and other general legislative or Congressional mandates such as the Omnibus Park Management Act and GPRA, and by NPS Management Policies. |
| • NONE: There is no legal mandate for this particular resource. |

participants could experience interactively how changes in the management significance, ecological significance, or legal mandate rankings could ultimately change the prioritization of vital signs for their park. The Vital Sign (VS) ranking team for each park varied but at a minimum included the Network Coordinator, Network Data Manager, Park Resource Manager, and Superintendent. Eight workshops were held from February through March 2005 (Table 3.2). The top ten vital signs, out of the candidate list of 57 vital signs, were numerically ranked for each park. The role of the VS Team was to present conceptual models and review their connection to park-specific management issues, to define terms, and to provide discussion for ecological concepts during the ranking process. The VS Team lead facilitator was Lisa Garrett, Network Coordinator. The Data Manager was responsible for recording key points of the discussion and to document any park-specific considerations involved in the numerical evaluations. Fifty-seven attributes were ranked (by one or more parks) during the series of workshops. See Appendix D-9 for a list of the top ten vital signs, in priority order for each park.

Table 3.2. Park prioritization workshops

| Date | Parks | Participants |
|---|---|---|
| February 1, 2005 | Whitman Mission National Historic Site | Superintendent, Chief of Interpretation and Resources Management, Education Specialist, Park Ranger Interpreter, Network Coordinator, Network Data Manager/Spatial Ecologist, Network Ecologist |
| February 3, 2005 | Nez Perce National Historical Park | Superintendent, Cultural Resource Specialist, Network Coordinator, Network Data Manager/Spatial Ecologist |
| February 23, 2005 | Big Hole National Battlefield | Superintendent (NEPE), Superintendent (BIHO), Cultural Resource Specialist, Park Ranger, Network Coordinator, Network Data Manager/Spatial Ecologist |
| February 24, 2005 | Lake Roosevelt National Recreation Area | Superintendent, Chief of Compliance and Natural Resource Management, Law Enforcement, Maintenance, Chief of Interpretation, Network Coordinator, Network Data Manager/Spatial Ecologist |
| March 1, 2005 | Hagerman Fossil Beds National Monument/Minidoka Internment National Monument | Superintendent, IT Specialist, Chief of Administration, Visitor Center employee, Chief of Operations, Natural Resource Specialist, Education Specialist, Paleontologist/Curator, Maintenance, Natural Resource Specialist – hydrologist, Network Coordinator, Network Data Manager/Spatial Ecologist |
| March 2, 2005 | City of Rocks National Reserve | Superintendent, Resource Ranger, Network Coordinator, Network Data Manager/Spatial Ecologist |
| March 3, 2005 | Craters of the Moon National Monument and Preserve | Superintendent, Interpretive Staff, Integrated Resource Program Manager, Ecologist (Botanist), Network Coordinator, Network Data Manager/Spatial Ecologist |
| March 30, 2005 | John Day Fossil Beds National Monument | Superintendent, Resource Manager, Network Coordinator, Network Data Manager/Spatial Ecologist, Network Ecologist |

E. Final Selection - "Short List" of UCBN Vital Signs

The overall goal of the UCBN vital signs selection process is to develop as comprehensive a program as possible such that it will yield information that is "greater than the sum of its parts". However, we recognize that no monitoring program can monitor everything and that monitoring is less expensive, easier, and ultimately more successful when the techniques are simple to use and when they focus on specific components of the ecosystem. Techniques which are easy to use will facilitate collection, analysis, and interpretation of data, and lessen the problems associated with handing over program responsibility to subordinates (Wright 1993). The latter point is important in parks because, as a long-term exercise, monitoring frequently involves many different people, each possibly for only a few years (Usher 1991). The UCBN feels that an emphasis in parsimony is critical to development of a successful long-term monitoring program and will undertake vital signs selection within this context.

In order for a monitoring program based on simple, discrete indicators, objectives, and measures to be truly comprehensive, however, the program must be well integrated both ecologically and programmatically. Following recommendations by Noss (1990) and others, the UCBN aims to develop an ecologically integrated program by selecting vital signs that span a range of spatial and temporal scales and span multiple levels of ecological hierarchy, from the genetic to the landscape level (Figure 2.2). Programmatic integration will require the consideration of other programs and projects ongoing within UCBN parks as well as other NPS networks and in other partnering agencies. A comprehensive and well integrated monitoring program requires careful crafting of vital signs and objectives, knit together with other existing programs.

The major challenge of the Vital Sign Prioritization process has been assembling a suite of vital signs that are insightful to park-level management concerns, provide understanding and status of ecosystem condition, and share value across all the parks in the network. The UCBN parks share some similarities (e.g., sagebrush-steppe habitat is present in 7 of 9 parks) but are also markedly different in size, enabling legislation, and in some parks ecological context. The network embraced these differences and similarities early on in the planning process. The resulting list of vital signs selected for monitoring demonstrate the network-wide perspective together with vital signs selected for specific park-level monitoring.

The Network decided on utilizing a SMART strategy for the final selection of vital signs. SMART stands for simple, measurable, accessible, reliable, and timely. All selected vital signs should meet these five criteria in order to be selected by the Network.

After completion of all the park-level workshops the Network Science Advisory Committee and Board of Directors decided on the "final" list of UCBN vital signs presented in Table 3.3. This list represents a comprehensive list of vital signs selected for monitoring (M), vital signs selected for data compilation (C), and future monitoring projects (FP).

Protocols will be written for the thirteen vital signs where monitoring is planned in the next five years. Examples of appropriate measures that could be monitored for each vital sign within the network framework are shown in Table 3.4. Sampling designs will be devised for each park so that data collected will address the monitoring objectives. Monitoring objectives will be further refined during the next couple of months.

The Network will use existing data collected by other agencies to complete the integrated monitoring program. The compilation of existing data will provide the Network with a well-balanced program at a fraction of the cost. The highest annual cost for the Network is in personnel costs. If fieldwork can be accomplished by other agencies and data compiled electronically the Network increases the cost to benefit ratio. The network will provide standard operating procedures (SOPs) for vital signs considered as “compilation” vital signs. The use of SOPs will ensure that compilation data is collected and synthesized in a systematic, useful manner that will assist park managers and superintendents in making informed management decisions (Table 3.5).

Justifications were written for each of the thirteen selected vital signs that summarize the resource issues being addressed. These justifications will be further developed during the writing of the protocol development summary required in Phase III for each of the vital signs selected by the Network. For additional details and associated conceptual models for these vital signs please see Appendix C. Conceptual Models.

<u>Invasive Plants</u> - Invasive plants represent one of the most significant threats to resources in national parks. Executive Order 13112 requires federal agencies to prevent the spread and introduction of invasive plants. The Executive Order includes the responsibility to “monitor invasive species accurately and reliably”. These species are often of concern given their abilities to reproduce prolifically, to rapidly colonize new areas, to displace native species, to alter ecosystem processes across multiple scales, and to detract from the interpretive value of park resources. Hobbs and Humphries (1995) identified a significant time lag between the initial establishment of an invasive exotic and its rapid expansion toward local carrying capacity. Early detection and control of invasive plants during this lag phase will likely require a lower overall expenditure of resources than those that have become well established. Therefore, monitoring changes in invasive plant species abundance and distribution provides critical information for allocating control resources.

During the vital signs selection process for the UCBN, invasive plant management was recognized across all nine parks as one of the most important shared resource management issue. An integrated monitoring protocol that includes predictive modeling and mapping may be most applicable to multiple parks.

<u>Sagebrush-steppe Vegetation</u> - The sagebrush-steppe ecosystem is the most widely distributed ecosystem type within the UCBN. The sagebrush-steppe region has undergone radical and extensive changes during the last 150 years (USDA Forest Service 1996, West and Young 2000, Bureau of Land Management 2002, Reid et al. 2002). Alteration of fire regimes, fragmentation, livestock grazing, and the addition of numerous exotic plant species have changed the character of sagebrush-steppe habitat in the UCBN. Overall this habitat has seen an increase in the diversity and abundance of exotic plants and a decrease in native bunchgrasses. More than half of the Pacific Northwest steppe habitat community types listed in the National Vegetation Classification are considered imperiled or critically imperiled (Anderson et al. 1998). In the

upper Columbia Basin, a number of unique and rare plants and animals are dependent upon healthy sagebrush-steppe plant communities.

Natural disturbance processes (e.g., fire) and human land-use activities including livestock grazing, timber harvesting, agricultural clearing and groundwater pumping alter watershed conditions and thus indirectly influence downstream riparian ecosystems. Localized impacts like the creation of trails within riparian corridors further degrade site-specific riparian conditions which can produce long-term changes in the structure and functioning of riparian ecosystems.

<u>Land Cover and Use</u> - Over ten years ago, the National Park System Advisory Board recommended that “resource management should be addressed in broader context” and specifically recognized the impact of activities outside park boundaries (National Park Service 1993). In fact, concerns over external influences date as far back as 1933 (Wright et al. 1933), and management of adjacent lands has been identified as one of, if not the most, serious challenge facing park managers over the last 25 years (Shands 1979, NPCA 1979, NPS 1980, Buechner et al. 1992). The majority of parks are dependent on adjacent lands simply because their boundaries fail to encompass habitats and processes (e.g., migratory species, fire regimes) necessary to maintain complete species communities (Myers 1972, Western 1982, Curry-Lindahl 1972, Garratt 1984). Therefore, threats from outside park boundaries can, and are, significantly modifying biodiversity within the parks (NPCA 1979, Garratt 1984, Sinclair 1998).

Monitoring long-term changes in landcover composition, configuration, and connectivity will help establish a broader context for each park, and can help natural resource managers determine patterns in land use change which may threaten future ecological integrity within parks. Selecting an adequate scale at which to evaluate the effects of landcover change and fragmentation is difficult without first identifying what is being managed (e.g. what species or processes; Beatley. 2000) and the scales of disturbance to which those species/processes respond. By developing and implementing a protocol to efficiently and cost effectively monitor landcover change within and around UCBN parks at multiple spatial scales, the current knowledge of park ecosystem dynamics will be further advanced, allowing for better management practices and decision making in the future.

<u>Water Quality – Macroinvertebrates</u> - Aquatic macroinvertebrate communities reflect water quality. Measures of macroinvertebrate community composition and structure have been frequently used as indicators because these communities integrate the effects of point and non-point source pollutants over spatial-temporal scales that are more appropriate to many management questions and more cost-effecitve to sample than many water chemistry parameters. Species richness of indicator taxa (e.g. mayflies, stoneflies, and caddisflies) and ratio of feeding guilds are two of several parameters frequently used as indices of relative water quality. Because of their utility as an integrated indicator of water quality and the condition of aquatic ecosystems, aquatic macroinvertebrates have been identified by the UCBN as a focal component for monitoring of aquatic ecosystems. Water quality will be assessed by comparing sampled index values to criteria for community structure in unimpaired or reference streams within the region (e.g. Barbour et al. 1999). Monitoring will also provide inventories of these communities for UCBN park water bodies, which currently lack species lists for most of the aquatic biota.

Table 3.3. UCBN Vital Signs selected for Monitoring (M), Compilation (C), and Future Projects (FP), shown by park unit.

| Level 1 | Level 2 | Level 3 - Vital Sign | Network VS Name | BIHO | CIRO | CRMO | HAFO | JODA | LARO | MIIN | NEPE | WHMI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Air and Climate | Air Quality | Ozone | | | FP | C | | | | | | |
| | | Visibility | | | | C | | | | | | |
| | | Air Contaminants | | FP | FP | C | FP | FP | C | FP | FP | FP |
| | Weather | Weather and Climate | | C | C | C | C | C | C | C | C | C |
| Geology and Soils | Geomorphology | Stream / river channel characteristics | | M | M | FP | | M | | | M | M |
| | Soil Quality | Soil function and dynamics | Soil erosion | | | | FP | | | | | |
| Water | Hydrology | Surface water dynamics | | M | M | | C | M | | | M | M |
| | Water Quality | Water chemistry | | C | C | C | C | C | C | | C | C |
| | | Toxics | | | | | | | C | | | |
| | | Aquatic macroinvertebrates | | M | M | FP | C | M | C | | M | M |
| Biological Integrity | Invasive Species | Invasive/Exotic plants | | M | M | M | M | M | M | FP | M | M |
| | Infestations and Disease | Insect pests | | C | FP | FP | | | C | | | |
| | Focal Species or Communities | Riparian veg.communities | | M | M | FP | M | M | M | | M | M |
| | | Shrubland vegetation | Sagebrush-steppe vegetation | M | M | M | M | M | M | | | |
| | | Freshwater communities | Springs / seeps | | FP | | | FP | | | | |
| | | Vegetation communities | Aspen | | M | M | | | | | | |
| | | Vegetation communities | Limber Pine | | | M | | | | | | |
| | | Vegetation communities | Pinyon-Juniper Woodland | | FP | FP | | | | | | |
| | | Forest vegetation | Forest structure | | | | | | FP | | | |
| | | Birds | Sagebrush-steppe Birds | | FP | FP | FP | FP | FP | | | |
| | | Birds | Riparian Birds | FP | FP | FP | FP | FP | FP | FP | FP | FP |
| | | Birds | Raptors | | FP | FP | FP | | M | | | |
| | | Birds | Sage grouse | | M | M | | | | | | |

Table 3.3 UCBN Vital Signs selected for Monitoring (M), Compilation (C), and Future Projects (FP), shown by park unit. (Continued)

| Level 1 | Level 2 | Level 3 - Vital Sign | Network VS Name | BIHO | CIRO | CRMO | HAFO | JODA | LARO | MIIN | NEPE | WHMI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Biological Integrity | Focal Species or Communities | Birds | Cliff swallows | | FP | | | | | | | |
| | | Mammals | Bats | | M | M | | M | | | | |
| | | Mammals | Pygmy Rabbits | | FP | FP | FP | | | | | |
| | | Terrestrial species | Peripheral / Relict Species | | FP* | | | FP* | | | | |
| | | Amphibians and Reptiles | | | | | | FP | | | FP | FP |
| | | Freshwater invertebrates | Freshwater Shrimp | | FP | FP | | | | | | |
| | | Terrestrial invertebrates | | | | | | FP | | | FP | |
| | At-risk Biota | Rare plants | | FP | | FP | FP | | FP | | FP | |
| Human use | Visitor and Recreation Use | Visitor usage | | | FP | | | FP | FP | | | |
| | Cultural Landscapes | Cultural Landscapes | Camas | M | | | | | | | M | |
| | | | Forest Structure | FP | | | | | | | | |
| Ecosystem Pattern and Processes | Fire | Fire and fuel dynamics | | C | C | C | C | C | C | C | C | C |
| | Landscape Dynamics | Land cover and use | | M | M | M | M | M | M | M | M | M |

M - Indicates that the UCBN is working to develop monitoring plans and protocols (also noted with shading)
C - Indicates that these vital signs are monitored by a network park or another federal or state agency and data will be compiled by the Network
FP - Indicates a vital sign that will be considered for a possible future project (no known current or planned monitoring - 2005)
A blank cell indicates that this vital sign was not "currently identified" for the park
* - Includes the following species: Ringtail, Canyon mouse, Pinon mouse, Western whiptail, Pika, and Cliff chipmunk

Table 3.4 UCBN Vital Signs Short List (monitoring planned for implementation within the next 5 years).

| Level 1 | Level 2 | Level 3 - Vital Sign | Network VS Name | Examples of Measures | BIHO | CIRO | CRMO | HAFO | JODA | LARO | MIIN | NEPE | WHMI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Geology and Soils | Geomorphology | Stream / river channel characteristics | | stream habitat structure, river depth, channel morphology (surveyed cross sections), cover and extent of riparian vegetation | X | X | | | X | | | X | X |
| Water | Hydrology | Surface Water Dynamics | | flow rate, annual water level fluctuation | X | X | | | X | | | X | X |
| | Water Quality | Water quality - macroinvertebrates | | species composition and abundance | X | X | | | X | | | X | X |
| Biological Integrity | Invasive Species | Invasive/Exotic plants | | percent area occupied, distribution, density, percent cover relative to native flora, early detection models | X | X | X | X | X | X | | X | X |
| | Focal Species or Communities | Riparian vegetation communities | | distribution & abundance of invasive riparian species, species diversity | X | X | | X | X | X | | X | X |
| | | Shrubland vegetation | Sagebrush-steppe vegetation | percent cover, composition and structure of sagebrush plant communities | X | X | X | X | X | X | | | |
| | | Vegetation communities | Aspen | percent cover, species composition, demographic vital rates, density of targeted plant communities | | X | X | | | | | | |
| | | Vegetation communities | Limber Pine | | | | X | | | | | | |
| | | Birds | Osprey | abundance, nest success, population growth rate, toxic residues | | | | | | X | | | |
| | | Birds | Sage grouse | | | X | X | | | | | | |
| | | Bats | | species presence/absence, roost exit counts, species/ community activity patterns | | X | X | | X | | | | |
| Human Use | Cultural Landscapes | Cultural Landscapes | Camas lily | distribution, percent cover, stem density | X | | | | | | | X | |
| Ecosystem Pattern and Processes | Land Dynamics | Land cover and use | | road density, housing density, landscape metrics, land use and land cover | X | X | X | X | X | X | X | X | X |

Table 3.5 Data sources and reference conceptual model for vital signs where data is to be compiled from outside sources.

| Vital Sign - National Level | Conceptual Model(s) | Examples of Measures | Data Source | BIHO | CIRO | CRMO | HAFO | JODA | LARO | MIIN | NEPE | WHMI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ozone | Global Model | Concentration, Cumulative exposure, Foliar damage | NPS Air Resources Division, Idaho Dept. of Environmental Quality | | | X | | | | | | |
| Visibility | Global Model | Light scattering, Light-extinction, Fine particles | NPS Air Resources Division, Idaho Dept. of Environmental Quality | | | X | | | | | | |
| Air Contaminants | Global Model | Organic pollutants, Fine particles, $CO_2$, Methane | NPS Air Resources Division, Idaho Dept. of Environmental Quality, Washington Dept. of Ecology | | | X | | | X | | | |
| Weather and Climate | Global Model | Temperature, Solar radiation, Precipitation, Snow depth, Wind | Western Regional Climate Center | X | X | X | X | X | X | X | X | X |
| Surface Water Dynamics | Lotic Submodel, Lentic Submodel | Flow rate, Volume | Idaho Power, US Bureau of Reclamation, US Geological Survey, Idaho Dept. of Water Resources | | | | X | | | | | |
| Water Chemistry | Lotic Submodel, Lentic Submodel | pH, DO, Conductance, Temperature, Cations, Anions, Turbidity | US Geological Survey, Idaho Dept. of Environmental Quality, Montana Dept. of Environmental Quality, Oregon Dept. of Environmental Quality, Washington Dept. of Ecology | X | X | X | X | X | X | | X | X |
| Toxics | Lentic Submodel, Osprey Submodel | Concentrations of priority metals | US Environmental Protection Agency | | | | | | X | | | |
| Aquatic Macroinvertebrates | Lotic Submodel | Presence/Absence, Density, Taxa ratios | US Fish and Wildlife (HAFO); US Environmental Protection Agency (LARO) | | | | X | | X | | | |
| Insect Pests | Forest Community Model | Presence/Absence, Seasonality | US Forest Service, Beaverhead-Deerlodge National Forest (BIHO); US Forest Service, Colville National Forest (LARO) | X | | | | | X | | | |
| Fire and Fuel Dynamics | Global Model, Sagebrush Altered Fire Regime Submodel, Forest Community Model | Occurrence, Severity, Timing, Extent | NPS Fire Management Program, National Interagency Fire Center, US Forest Service, Bureau of Land Mgt. | X | X | X | X | X | X | X | X | X |

Surface Water Dynamics – (Key legal mandates: Clean Water Act, Rivers and Harbors Act – Section 10, Executive Order 11988 - Floodplain Management, NPS Director's Order 77-2 – Floodplain Management, Management Policies §4.6.6) Water quantity monitoring is essential for evaluating ecological issues in UCBN parks. Available water is one of the key drivers of ecosystem function in the arid and semi-arid parks of the region and provides insights into overall system productivity, shifts in species abundance and distributions, water quality and nutrient cycles, the occurrence and ecosystem response to disturbance events, etc. Groundwater overdrafts in the Snake River plain are a leading anthropogenic stressor as agricultural and urban development adjacent to UCBN parks have increased dramatically since the mid-20th century.

Stream / River Channel Characteristics – (Key legal mandates: Clean Water Act, Rivers and Harbors Act – Section 10, Executive Order 11988 - Floodplain Management, NPS Director's Order 77-2 – Floodplain Management, Management Policies §4.6.6) Rivers are dynamic systems that are subject to rapid changes in channel shape and pattern, streamflow, sediment transport, and sediment storage. Changes in these stream processes can indicate changes in land use or watershed conditions. An understanding of stream morphology, discharge, and stream sediment storage and load can help document channel response to human induced environmental changes such as agricultural practices, mining, dredging, logging, roads, and urbanization. For example, changes in sediment yield can reflect changes in basin conditions, including soil quality, erosion rates, vegetative cover, and hillslope stability. Watershed disturbances such as floods, fire, and land uses can significantly alter the sediment supply to streams. In turn, fluctuations in sediment discharge affect many ecosystem processes both biotic and abiotic. Nutrients are transported with the sediment load. Higher suspended sediment loads and turbidity directly affect aquatic organisms and higher sediment transport can impact the quality of stream habitat and riparian systems.

Monitoring channel morphology for primary drainages in UCBN parks provides an important indicator of watershed condition, and integrates several ecological and geomorphological processes in the region, such as soil erosion, nutrient cycles, the occurrence and magnitude of disturbance events, surface and groundwater quantity and quality, and the abundance and distribution of riparian obligate species. Rare, stochastic flow events are of particular importance in the arid and semi-arid parks of UCBN. Channel morphometrics provides critical evidence of the frequency, magnitude, and duration of these events, as well as the consequences of land management practices on watersheds containing UCBN parks. Culturally significant areas may also be threatened in some UCBN parks.

Aspen Community - Quaking aspen (*Populus tremuloides*) is declining rapidly in the western United States. Aspen decline compared to historic distribution range from 49% in Colorado to 96% in Arizona, with an estimated loss of 61% in Idaho (Bartos 2001). Aside from riparian ecosystems, aspen communities are the most biologically rich areas in the intermountain west and act as a keystone species (Kay 1997). Aspen decline cascades into losses of vertebrate species and vascular plants as well as invertebrates and nonvascular organisms (Campbell and Bartos 2001). Aspen is furthermore listed as a sensitive species within the USDA Forest Service's Ozone Biomonitoring Program and with the NPS Air Resources Division.

Native ungulates and domestic livestock utilize aspen for preferred forage (Barnett and Stohlgren, 2001; Shirley and Erickson, 2001) and may inhibit successful regeneration in aspen stands (Bartos and Campbell, 1998; Kay and Bartos, 2000). Current fire intervals, extents and intensities are not killing and regenerating aspen at historic rates, and are a likely cause to the aspen decline observed today.

Limber Pine – A relative of whitebark pine, Limber pine *(Pinus flexilis) is* susceptible to whitepine blister rust, an exotic fungus for which limber pine has evolved few defenses. Although blister rust has higher moisture requirements than limber pine, changing climatic conditions makes it unlikely that limber pine in UCBN will remain unaffected. While some individual trees are naturally resistant to blister rust, once infected, most trees will die. Baseline monitoring of disease disturbances in the UCBN is important to understand landscape and stand level changes in the vegetation and fuels structure. In addition, this data will provide park managers with information needed to detect changes that might lead to resource impairment.

Bat Community - Properties of faunal assemblages and populations may be important indicators of environmental change because fauna serve a great diversity of ecological functions that affect ecosystem productivity, resilience, and sustainability (Marcot et al. 1996). Terrestrial fauna also are desirable subjects for long-term ecological monitoring because they have widespread public appeal, and changes in the park's fauna are likely to garner a high level of public interest and generate support for corrective or remedial management actions. Bats exhibit high fidelity to foraging and roosting sites, extreme longevity, and are highly mobile. These characteristics suggest that changes in species presence, composition, activity levels, and demographic structure at monitoring sites in the UCBN will likely serve as good indicators of environmental change (Fenton 2003). Because bats concentrate foraging around riparian and open aquatic habitats, bat monitoring may be an important element to an integrated monitoring program for wetland/riparian and aquatic focal systems in the UCBN. In the UCBN, maternity roosts for colonial species, such as the Townsend's big-eared bat and pallid bat, are located in cliffs and caves that experience heavy visitation. Monitoring of these sites over time could provide invaluable information to managers about visitation impacts. New emerging acoustic monitoring technology will enable the UCBN to monitor bats efficiently and in a cost effective manner in remote locations.

Osprey - Ospreys (*Pandion haliaetus*) are found worldwide, on every continent except Antarctica, and are a common breeding resident along Lake Roosevelt National Recreation Area. When nesting, ospreys are highly adaptable, building large, stick nests on both natural and artificial nest sites, including channel markers, power poles and specially built nesting platforms. During the 1950s and 1960s, pesticide contamination threatened many osprey populations. Egg viability fell drastically, depressing hatching rates and eventually breeding numbers as well. Historically, there has been little monitoring of osprey populations in this region other than casual observation.

Many characteristics of osprey make them ideal biological indicators. Not only are they top predators and specialists, but >99% of the fish eaten is captured near the nest site. They often build large, visible nests that are regularly spaced along lake shores making them ideal candidates for assessing changes in spatial patterns. Osprey are long-lived, mate for life, and typically return to the same nest each year (US Geological Survey 2003).

The proposed objectives of osprey monitoring at LARO is to provide baseline data on the size and composition of the local osprey population, document annual fluctuations within this population and determine annual nesting trends, nesting productivity (fledges per nest) and nesting success by nest structure and location (manmade vs. natural).

<u>Camas lily</u> - Some species have been identified by the UCBN as network species/communities of concern due to their cultural significance. One example is Camas which is a plant of cultural importance to the Nez Perce tribe. While not specifically covered under the Endangered Species Act or state policies/laws, providing monitoring information to resource managers on distribution and abundance will lead to the implementation of conservation activities that will help further the persistence of Camas at BIHO and NEPE.

<u>Sage grouse</u> - Sage-grouse (*Centrocercus urophasianus)* populations have been declining throughout western North America and today, their populations are thought to be only a fraction of their original numbers. Several park units within the UCBN have leks sites located within the park boundaries that are not currently monitored. The UCBN will help identify sage-grouse population trends through a lek monitoring program at CIRO and CRMO. The Network will use citizen science, following Idaho Fish and Game protocol, to expand sage-grouse population trend data through lek monitoring, and to increase the public awareness concerning sage-grouse life history and sagebrush ecology.

F. Candidate Vital Signs Selected for Future Projects

Many of the original candidate vital signs were not selected for initial monitoring under the UCBN Vital Signs Monitoring Plan. Greater functional understanding of park ecosystems can be obtained by monitoring more system components than by fewer. However, in keeping with our “do fewer things better” program philosophy, it was understood that our selected sets of vital signs should be small and, ideally, functionally coherent and interconnected. Therefore, several candidate vital signs were ranked lower in our prioritization processes for a variety of reasons (some are provided in Table 3.6). Some lower ranked vital signs, not selected for initial monitoring by UCBN, but considered for future projects include:

- *Air Contaminants:* The UCBN has one park (CRMO) that is classified as a Class I airshed and currently has air quality monitoring. The feasibility and cost to include additional parks in a similar program was not currently considered cost-effective with a limited monitoring budget.
- *Insect Pests:* The presence of *Ips confusus* (the pinyon *Ips*) in red-topped and dead pinyon pine has been confirmed at CIRO. This bark beetle species is probably the cause of much of the observed mortality in pinyon pine within the reserve. Dr. Steve Cook, University of Idaho researcher, recommended that a systematic survey of pinyon mortality should be conducted. Insect pests have been identified by park management as a vital sign but a significant lack of information exists and targeted research is needed.

- *Sagebrush-steppe Birds:* The UCBN recognizes that monitoring birds could be an important component of a biodiversity monitoring program. However, the use of birds as ecological indicators has been questioned because determining the effect of environmental changes on bird populations is very difficult given the myriad of factors that can cause population changes (Morrison 1986, Temple and Wiens 1989). In addition there is the added cost of using the double-observer variable circular plot method and the additional expertise necessary to accurately identify bird species. It was decided that vegetation community monitoring took precedence because data from vegetation monitoring would better address identified monitoring questions. The network has identified bird monitoring as a possible future project, if monies become available.

- *Periperal / Relict Species:* The area in and around CIRO, in southern Idaho, coincides with a unique biogeographic setting where the pinon-juniper woodland reaches its northern distributional limit, occurs in conjunction with large granite cliffs, and supports a diverse but poorly described mammalian fauna associated with these features, including several rare species also at their northern distributional limit and found nowhere else in Idaho. Park management has written a proposal to address this knowledge gap by conducting an integrated sampling effort involving several techniques to provide new information on the distribution, abundance, and habitat association of the ringtail, cliff chipmunk, pinyon mouse, canyon mouse, and, if present, the brush mouse. When, and if, this inventory information becomes available then a possible monitoring project could be initiated, if funding is available.

- *Freshwater Shrimp:* Three new species of fairy shrimp have been documented in Idaho since 1996. Six species of fairy shrimp are known to reside in Idaho. The shrimp, a member of the genus *Branchinecta*, are small crustaceans. The shrimp eggs can lay dormant for up to 10 years before a heavy rain event, with flooding or rapid snowmelt will cause a big enough change in the pH to trigger a hatch. Insects, birds and amphibians prey on fairy shrimp, making them an important link in the food web, especially for migrating birds. More inventory and research information is necessary before protocols for freshwater shrimp could be developed due to the complexity of evaluating data about this little known organism.

For a list of vital signs considered but not selected by the monitoring program and reasons for developing these vital signs as possible future projects see Table 3.6.

Table 3.6 UCBN vital signs not selected for monitoring but identified as possible future projects.

| Parks | Vital Sign Name | Reason for Lower Priority Ranking |
|---|---|---|
| CIRO | Ozone | Low score – limited to one park |
| Network | Air Contaminants | Feasibility and cost |
| CRMO | Stream / River Channel Characteristics | Low score |
| HAFO | Soil Erosion | Feasibility and Cost |
| CRMO | Aquatic Macroinvertebrates | Low score |
| CIRO, CRMO | Insect Pests | Research needed |
| CRMO | Riparian Vegetation Communities | Low score |
| CIRO, JODA | Springs / Seeps | Lack of inventory data |
| CIRO, CRMO | Pinyon-Juniper Woodland | Objectives not clearly understood |
| LARO | Forest Structure | Objectives not clearly understood |
| 5 parks | Sagebrush-steppe Birds | Feasibility and cost |
| Network | Riparian Birds | Feasibility and cost |
| CIRO, CRMO, HAFO | Raptors | Low score |
| CIRO | Peripheral / Relict Species | Lack of inventory data / research needed |
| CIRO | Cliff Swallows | Limited to one park |
| CIRO, CRMO, HAFO | Pygmy Rabbits | Presence not documented in parks |
| CIRO, CRMO, | Freshwater Shrimp | Lack of inventory data |
| JODA, NEPE, WHMI | Amphibians and Reptiles | Low score |
| JODA, NEPE | Terrestrial Invertebrates | Inventory and research needed |
| 5 parks | Rare Plants | Low score - research needed |
| CIRO, JODA, LARO | Visitor Usage | Objectives not clearly understood |
| BIHO | Forest Structure (Cultural Landscape) | Limited to one park |

# Chapters 4-10. Next Steps

The UCBN will submit this report on June 1, 2005 to Dr. Penny Latham, Pacific West Regional I & M Coordinator and three additional reviewers. The reviewers will be asked to review this Phase II report using a checklist that has been designed for the review of vital signs monitoring plans. The reviewers will be asked to submit their comments within 30 days to Dr. Latham and Lisa Garrett, UCBN Coordinator. Dr. Latham will compile the reviews and give feedback to the Network on comments received from the reviewers.

The Network will submit the final draft of the Phase II, incorporating changes suggested in the review process, on October 1, 2005 to Dr. Steve Fancy (NPS National Monitoring Coordinator). The Upper Columbia Basin Network I & M team will begin work on the Phase III Monitoring Plan immediately upon completion of the Phase II report on June 1, 2005. The Phase III Monitoring Plan, due on December 1, 2006, is the complete monitoring plan. Additional chapters will be added to the Phase II plan on sampling design, sampling protocols, data management, data analysis and reporting, administration and implementation of the monitoring program, schedule, and budget for the vital signs selected for monitoring.

*Additional Chapters to be Added in the Phase III Report include:*
Chapter 4. Sampling Design
Chapter 5. Sampling Protocols
Chapter 6. Data Management
Chapter 7. Data Analysis and Reporting
Chapter 8. Administration/Implementation of the Monitoring Program
Chapter 9. Schedule
Chapter 10. Budget

# Chapter 11. Literature Cited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# Glossary of Terms Used by the NPS Inventory and Monitoring Program

**Attributes** are any living or nonliving feature or process of the environment that can be measured or estimated and that provide insights into the state of the ecosystem. The term **Indicator** is reserved for a subset of attributes that is particularly information-rich in the sense that their values are somehow indicative of the quality, health, or integrity of the larger ecological system to which they belong (Noon 2002). See Indicator.

**Ecological condition** is the sum total of the physical, chemical, and biological components of ecosystems and how they interact. Ecological condition reflects the non-equilibrium character of ecosystems, in which routine natural disturbances such as fire, herbivory, and climatic extremes play important roles.

**Ecological integrity** is a concept that expresses the degree to which physical, chemical, and biological components (including composition, structure, and process) of an ecosystem and their relationships are present, functioning, and capable of self-renewal. Ecological integrity implies the presence of appropriate species, populations and communities and the occurrence of ecological processes at appropriate rates and scales as well as the environmental conditions that support these taxa and processes.

**Ecosystem** is defined as, "a spatially explicit unit of the Earth that includes all of the organisms, along with all components of the abiotic environment within its boundaries" (Likens 1992).

**Ecosystem drivers** are major external driving forces such as climate, fire cycles, biological invasions, hydrologic cycles, and natural disturbance events (e.g., earthquakes, droughts, floods) that have large scale influences on natural systems.

**Ecosystem management** is the process of land-use decision making and land-management practice that takes into account the full suite of organisms and processes that characterize and comprise the ecosystem. It is based on the best understanding currently available as to how the ecosystem works. Ecosystem management includes a primary goal to sustain ecosystem structure and function, recognition that ecosystems are spatially and temporally dynamic, and acceptance of the dictum that ecosystem function depends on ecosystem structure and diversity. The whole-system focus of ecosystem management implies coordinated land-use decisions.

**Focal resources** are park resources that, by virtue of their special protection, public appeal, or other management significance, have paramount importance for monitoring regardless of current threats or whether they would be monitored as an indication of ecosystem integrity. Focal resources might include ecological processes such as deposition rates of nitrates and sulfates in certain parks, or they may be a species that is harvested, endemic, alien, or has protected status.

**Indicators** are a subset of monitoring attributes that are particularly information-rich in the sense that their values are somehow indicative of the quality, health, or integrity of the larger ecological system to which they belong (Noon 2002). Indicators are a selected subset of the physical, chemical, and biological elements and processes of natural systems that are selected to represent the overall health or condition of the system.

**Measures** are the specific feature(s) used to quantify an indicator, as specified in a sampling protocol.

**Stressors** are physical, chemical, or biological perturbations to a system that are either (a) foreign to that system or (b) natural to the system but applied at an excessive [or deficient] level. Stressors cause significant changes in the ecological components, patterns and processes in natural systems. Examples include water withdrawal, pesticide use, timber harvesting, traffic emissions, stream acidification, trampling, poaching, land-use change, and air pollution.

**Vital Signs**, as used by the National Park Service, are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. The elements and processes that are monitored are a subset of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. Vital signs may occur at any level of organization including landscape, community, population, or genetic level, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).